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MACHINERY:

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A PRACTICAL JOURNAL FOR MACHINISTS AND ENGINEERS
AND FOR ALL WHO ARE INTERESTED IN MACHINERY:

MACHINERY.

VOL. 3. June, 1897. No. 10.

MECHANICAL LABORATORY, PRATT INSTITUTE.

ARTHUR L. RICE.

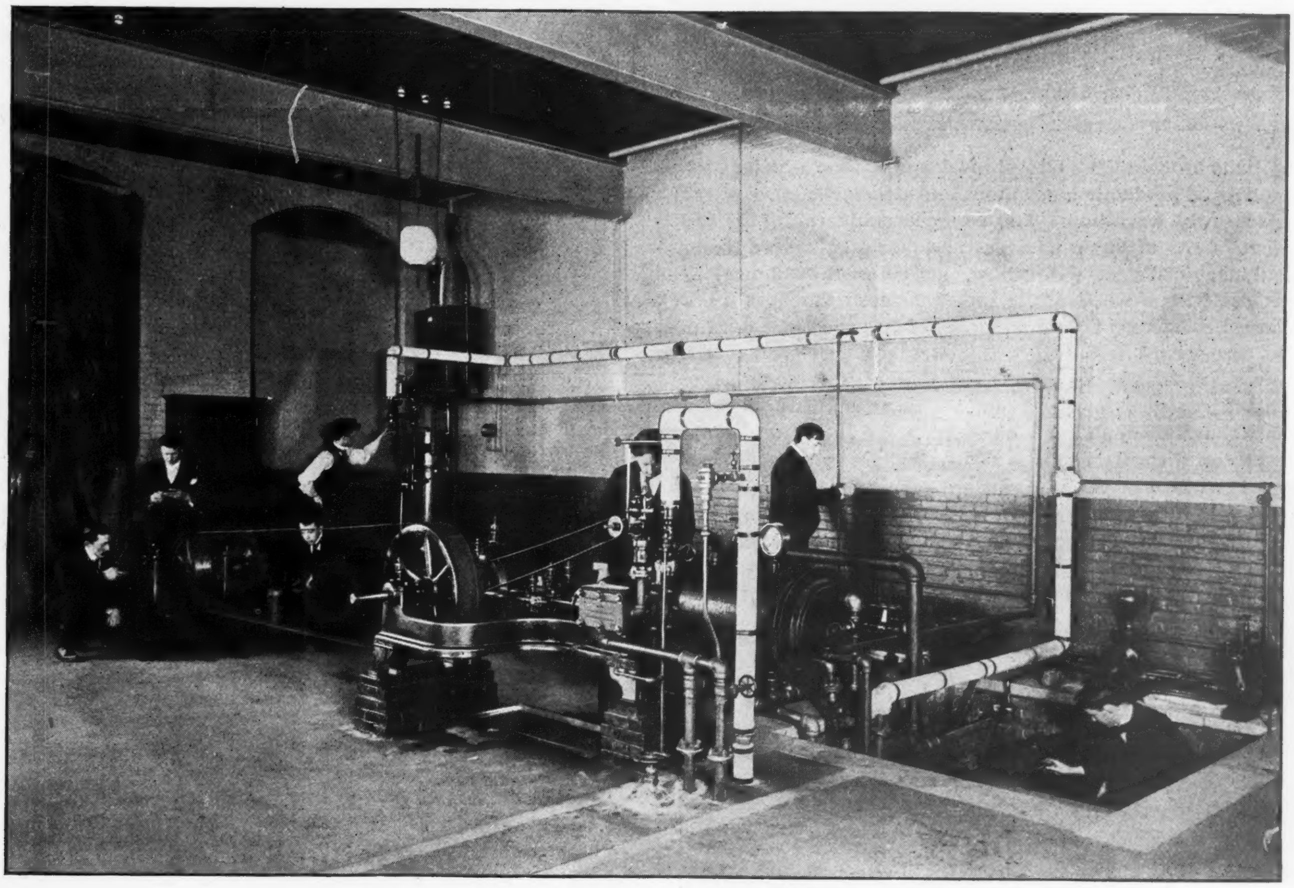
ALTHOUGH much original designing has been done by graduates of this department, still the chief object of the technical courses at Pratt Institute is not to train engineers and investigators, but to fit young men for positions in the drafting-room and power-house. With this object in view the courses and the treatment of the subjects are planned; and the equipment of the laboratory has also been designed for this purpose.

The laboratory work for the mechanical drawing class is in connection with the study of the steam engine and of the strength of materials. The courses and experiments are laid out with the purposes of illustrating and emphasizing class-room work and giving familiarity with machinery; and also of letting the student discover for himself natural phenomena and laws. For instance, in the experiment on setting the D valve, two or more valves are used and the effect on the card of changing lap and lead are learned by actual observation. For the purposes of the course a 7 x 8 vertical engine and a 6 x 8 horizontal are arranged with Alden brakes, indicators, calorimeters, a condenser, weighing tanks, scales and pumps. The vertical engine is arranged for valve setting and minor experiments, and has only atmospheric exhaust. The horizontal, by a duplicate system of piping, can be made condensing or non-condensing, at will. It is used for valve setting and for testing under various conditions. The smaller apparatus of a laboratory, as indicators, planimeters, scales and thermometers are also provided.

In the materials course, the object has been to give a thorough understanding of the action of various materials under stress, so that the student may realize where and when each material should be used. For this purpose, it is considered that the testing performed on wire specimens is as instructive as if done on larger pieces, the machines are much less expensive and occupy less room besides allowing of individual work. For these reasons twelve of the small dial machines, seen in figure 2, have been designed and constructed for individual testing of wire. These machines are also provided with yokes in which small wooden cross-breaking specimens of various lengths may be tested to learn the laws of variation of the strength of beams with varying dimensions. Besides these, there are provided a 300 000 pound Olsen machine for tension and compression, a 1 500 pound Olsen cement tester and a torsion machine, constructed at the Institute, which will test specimens up to ¾ inch in diameter. These are shown on the following page, together with a view of the pump model, which gives students a good idea of the workings of a duplex steam pump. This is mounted on a stand having rollers, so that it can be readily moved to any part of the room.

The equipment, though small, is found very convenient and large enough for the divisions, which are limited in number to twelve students.

On the opposite side of the laboratory, space is reserved for the installment of a 40 HP. engine, dynamos, motors, a switch-board and measuring instruments, which are to be installed the coming summer, for the work of the class in applied electricity, which will have its first laboratory work next year.



CORNER OF MECHANICAL LABORATORY, PRATT INSTITUTE, BROOKLYN, N. Y.

* * *

AT a late meeting of the Providence Association of Mechanical Engineers, Mr. Wm. A. Viall, superintendent of the small tool department of the Brown & Sharpe Mfg. Co., read an instructive paper entitled "Measuring Instruments." He gave an interesting account of the growth of the present standards of measurement, and told of the refinements of measuring as daily practiced by the Brown & Sharpe Mfg. Co. The Providence Association of Engineers is a growing organization.

FINE MEASUREMENTS ON DRAWINGS.

E. LAWRENZ.

At the time of the wooden lathe bed and other crude machine parts, drawings, if used at all, were in a similar primitive state, and, indeed, one need not go so very far back to find drawings made with chalk on a piece of board simply giving a bare idea of what was required. Modern machine shop practice, however, cannot tolerate such a state of affairs and only the best satisfies all the

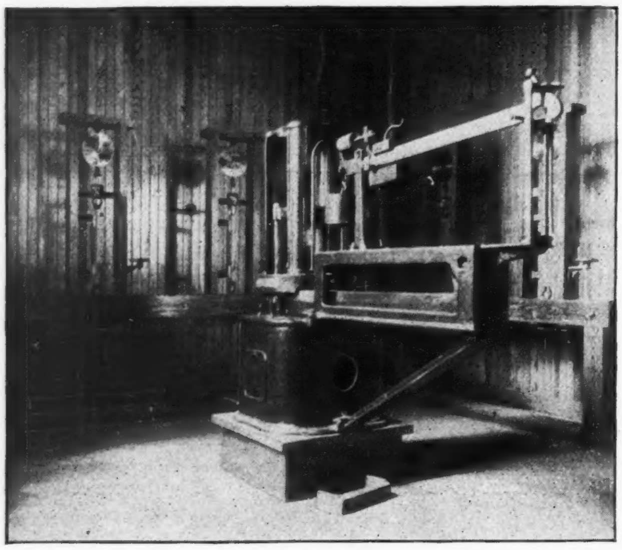
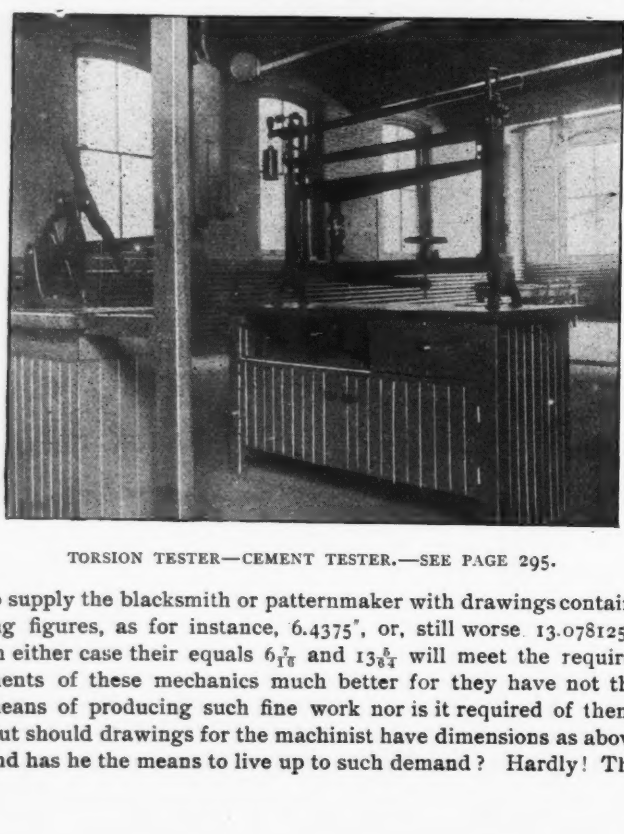


FIG. 2.—OLSEN TESTER AND SMALLER TESTERS.—SEE PAGE 295.

conditions brought about by shrewd competition which gives us cheapness of production, accuracy, and a perfect control over the product of the workshop. The advance made during the development of the machine business necessarily advanced the individual machinist's art, so much so, that where the old machinists measured with a wooden rule and considered the boss a crank because he objected to an inaccuracy of $\frac{1}{16}''$, the same machinist of his own accord does work within limits of .001" and even less to-day.

This it true even if 99 per cent. of all machinists object and declare that they don't know what an .001" is and very emphatically protest that all they use is a pair of calipers set to a steel scale. But they always succeed in getting any number of pieces alike so that you could not detect the difference with your new styled micrometers, vernier-gages and other outlandish things only fit to confuse a fellow. The question remaining is "should dimensions be given in the form of decimals?" It certainly will not do

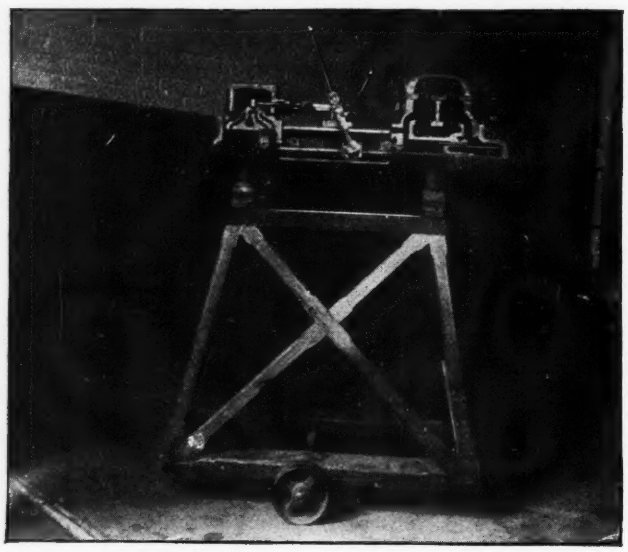


TORSION TESTER—CEMENT TESTER.—SEE PAGE 295.

to supply the blacksmith or patternmaker with drawings containing figures, as for instance, 6.4375", or, still worse 13.078125". In either case their equals $6\frac{7}{16}$ and $13\frac{5}{64}$ will meet the requirements of these mechanics much better for they have not the means of producing such fine work nor is it required of them. But should drawings for the machinist have dimensions as above and has he the means to live up to such demand? Hardly! The micrometer of today does not measure so closely with absolute correctness, and, indeed, no two micrometers will coincide throughout their whole range. This guesswork becomes more distinct in the case of vernier-gages for no two men will read the same gauge absolutely alike.

What then is the use of saying that the diameter of a given roll must be 5.4376" or some other fancy figure? Is it not much easier to say $6\frac{7}{16}''$? Don't the fellows in the shop understand this better? No doubt it is simpler to say $6\frac{7}{16}''$ and it is better understood but this would not fully satisfy all conditions. Decimals on drawings should be looked upon as imperative, pointing out the degree of accuracy to be attained. It would be nonsense to measure $6\frac{7}{16}''$ to the tenth of a thousandth when an inaccuracy of $\frac{1}{100}''$ or even $\frac{1}{64}''$, could be permitted. Decimals demand greater accuracy while vulgar fractions permit slight variations. In other words a statement of magnitude expressed decimally means that the error of variation must be brought down to the smallest amount possible and should always be given on drawings for precise work where accuracy is the main object sought.

For manufacturing purposes the conditions are somewhat different. No one will think of producing any number of parts and have other workmen measure the work with different micrometers. Every foreman will see that the workman has suitable gages particularly adapted for the work to be done, providing for the limit of variation, and their capacity and purpose stamped in a conspicious place; hence drawings for manufacturing purposes *may* have all dimensions in decimals even if in the figure given no fraction of the unit appears, as 6.000", etc., because there is no room left for any one to guess.



SECTION OF DUPLEX STEAM PUMP.—SEE PAGE 295.

Take the measurement of angles and bevels as they come up in machine shops. Can any one exactly measure 33° 43′ 51″, or is there any gauge that will measure the above quantity unerringly and easily, or any tool which will produce such work cheaply and practically for commercial purposes? It is difficult to find two protractors exactly alike, and the divisions on planer heads or on lathe taper attachments can hardly ever be relied upon with perfect safety. Some lathe taper attachments have in addition to the angular measurements a scale of chords or their equivalents, but the difficulty is that sufficient explanation is not given for its use, although a good deal of information of this kind may be obtained from trade catalogs, if men only knew how to select and apply it. This scale of chords is a step in the right direction, and to supplement it, drawings should contain in addition to degrees (minutes and seconds, if it cannot be avoided), the values of the sides of the triangle of which the bevel or taper is some element, so as to clearly point out their meaning and thus assist the workmen in every respect. This may seem superfluous, but it is not, since it is the drawing's mission to help the work along in every instant.

* * *

THE National Association of Manufacturers (headquarters in Philadelphia, Pa.) have issued a 119 page pamphlet, giving the results of the investigations of their commission in Argentine, Uruguay and Brazil.

FROM ACTUAL PRACTICE.

"MILO."

SHOP MANAGEMENT—PRISON SHOPS.

There were several machine shops in Hardscrabble, large, small, good, bad and indifferent, which made it an interesting town for an observing mechanic.

Buster's shop was a room about 10 x 35 feet, with a small engine and boiler in one corner and his desk in the other. An emery wheel, grindstone, a few old vises, chain-driven planer, three chain-feed lathes, upright drill, speed lathe and a lot of small scrap completed the equipment.

One Saturday a mere boy, stranger in town, walked in and said he wanted to learn the machinist's trade. After some questioning Buster concluded to hire him at $5.00 per week; so when Monday morning came Push was on hand promptly to begin work.

It was one of those cold, dark mornings in January, and a smoky lantern hanging near the boiler permitted Mr. B. to be seen with overcoat and mittens on, standing back to the boiler waiting for the fireman, a boy about 12 years old, to get up steam to warm the shop and drive the machinery, for there had been no heat in the building since Saturday. There was nothing for Push to do but to wait also, and it was 9 o'clock before work was begun. He was given a number of small pulleys with instructions to block them up on the face plate, as there was no chuck, and bore them out. Two of the arms on one were cracked during the chucking operation, and another was broken while fitting a shaft to it.

After waiting two hours more for steam the next morning everything went smoothly until he was informed through the fireman that he must not expect to get paid for the time lost waiting for steam. But he said, "I was here ready to begin work, and shall collect pay for it." So when he arrived the next morning he was given some pulleys to paint while Buster stood around the boiler to keep warm. In this way the week was completed, and when pay time came, all he got was a check on the Hardscrabble National Bank for $3.66, being docked for four hours lost time and $1.00 for breaking two pulleys that cost, time and all, less than 25 cents each.

Monday morning found Push again on hand, but he was missing in the afternoon. Next day he worked a few hours more, and so on until Saturday night, when he had 36 hours to his credit, so he got another check for $2.88 and his dismissal thrown in, "Because," said Buster, "you don't work steady enough to amount to anything, nearly half your time being spent looking for another job," which he got at the next shop, and made a very satisfactory workman.

Not far from Buster's shop is another, employing hundreds of hands instead of two, and it is one of the best known shops in the country. There is an elaborate office fitted up for the time-keeper, who sits by a bolted door of fine finish, to take the name of every man that comes in late, and he is docked one hour, even if he is only a second late, and he must go to work at once unless he remains outside the shop. If he goes out early it is the same way, he must loose an hour even if he only wants five minutes to catch a train.

One day a man went there and hired out, proved to be a good steady fellow and a satisfactory workman, so he staid there several years, but when he asked for more pay he was told to "Wait until to-morrow and I will let you know." They kept him waiting a whole week, so that the month's pay roll would be made up before his rate was changed, which was equivalent to putting him off a whole month.

He said nothing about that, but one Monday morning he was a trifle later than usual, and the engineer for some cause or another blew the whistle a little early, which caused the door to be locked in his face, and he had to pass through the office. He warned the time-keeper not to dock him, as it was yet two minutes of seven (which the time-keeper acknowledged), and he did not want to loose an hour's time unless he was late. But the whistle had blown and that settled it. When ten hours was found on time card the next morning an errand boy was send up for an explanation. Then the clerk requested him to change it, which he refused to do. Finally the foreman and superintendent took it up and decided that he must not be paid for more than nine hours, so he gave his notice to "quit" the following month.

In one of the suburban towns less than an hour's travel from your desk, Mr. Editor, is a factory employing thousands, and if any of the help is late they are locked out until 9 o'clock, regardless of circumstances. Quite a number come to work by train, and if it was delayed by a storm it would make no difference, they must remain outside exposed to the elements or seek shelter in some of the neighboring houses or saloons until 9 o'clock. Such a company may sell their product to those who are willing to buy it, but if the public at large knew these things I am quite certain that I am not the only one who would refuse to have one of their sewing machines in the home.

I am told that if a man is not there on pay day he can obtain a sort of check, which will permit him to collect his wages the following Monday. One man had given his notice and finished his work for good. Monday noon he went in with his check, collected his pay and was talking with the boss, when the whistle blew, so he was locked in and required to get a pass from the superintendent before getting out. He went back and explained the situation to his foreman, but it was of no use, he must get an order from the superintendent, or wait until 6 o'clock. That was more than he could stand, and he took out his hammer and started down stairs, saying that he was going out, door or no door. The foreman, seeing that he meant what he said, telephoned down, and as soon as he came in sight the door swung wide open from the effects of some influence exerted on the bolt by means of the chain that connected it with the interior of the office.

Here we have some of the things that exist in the different types of American workshops, which their managers must feel proud of. What do the readers of this paper think of them ?

* * *

WE have been favored with a bound volume of *The Locomotive* for 1896, which will be placed in our reference library for future use. These volumes are valuable to any engineer, and taken as a whole, form a very complete record of boiler explosions, as well as latest boiler practice.

* * *

FORCING FITS.

Mr. W. A. Bole, superintendent of the Westinghouse Machine Co., sends the following data regarding their practice:

"We send you data of our practice, and in explanation will say that our cranks are of open hearth steel castings; they are bored smooth and keyseated. The ends are also open hearth steel turned with allowances as here given and pressed into place by a strong hydraulic press.

"The largest size of all is heated before the end is pressed in and the others are regularly pressed in at ordinary shop temperatures. We have put together several thousands of such press fits and with almost absolutely uniform security. The fits are smooth and free as possible of feed marks."

Engine.	Diameter of Hub.	Diameter of Bore.	Length of Hub.	Allowance for Fit.	Allowance per inch Diameter.	Pressure in Tons.	Pressure per Square Inch.
	Inches.	Inches.	Inches.	Inches.	Inches.	Tons.	Pounds.
4½ x 4	3½	1⅝	1⅜	.006	.0035		
5½ x 5	4¼	2	2⅜	.006	.003	3	1900
6½ x 6	4½	2⅜	2⅜	.007	.0029	6	2700
7½ x 7	4½	2⅜	2½	.008	.0033	8	3500
						10	
8½ x 8	5½	2¾	2¾	.008	.0029	12	3600
						15	
9½ x 9	6¼	3	3⅛	.010	.0033	18	4600
						20	
11 x 10	7¾	3½	3⅜	.010	.0028	25	5600
						25	
12 x 11	8	3¾	3⅝	.012	.0034	35	5400
						30	
13½ x 12	8½	4¼	4½	.012	.0028	35	4600
						35	
14½ x 13	8½	4½	5	.012	.0033	40	4600
						40	
15½ x 14	9½	4¾	5¼	.015	.0034	45	4800
						60	
18 x 16	12	5¾	5¾	.015	.0026	70	5000
						30	
12 x 20	8½	4¼	4¼	.015	.0033	35	4600
						40	
13 x 22	11	5½	5$\frac{9}{16}$	.015	.0024	45	3600
						45	
14 x 24	14	6	6	.015	.0025	55	3500
						60	
16 x 27	14½	6¾	6¾	.015	.0022	75	3900
						65	3400
18 x 30	15	7	7	.015	.002	85	4000
						100	2800
23 x 40	18	9½	9½	.015	.0015	120	*3300

* Hubs heated to 250° or 300° before pressing shaft in.

EVERY-DAY SHOP SUBJECTS.—6.

CHIPS.

TOOLS AND TOOL-POSTS—A STEAM SQUEEZER—TWO WAYS OF MAKING CONNECTING-ROD ENDS.

A friend recently showed me a tool he was using for cutting off small stock, which may help some other fellow out of a hole, so I give it. He used the tool-holder shown in Fig. 1, which is simply a piece of soft steel of the right size for the tool-post, planed out for a smaller size steel as shown. These are common—have

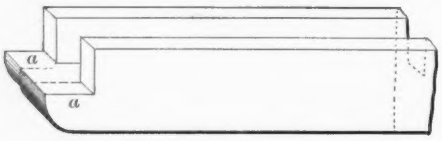


FIG. 1.

FIG. 2.

used one myself for years. The projecting lip *a a* is not common, but it makes a good support for tool and can generally be set pretty close to the work. The tool in this case was a thin piece of tool steel as *a* in Fig 2, which is held by strips *b* and *c*, which, with the tool *a* between them, just fill the groove, making a pretty solid job, and leaving little for the tool-post screw to do. The pieces *b* and *c* were of die-drawn machine steel, which is quite exact in size and very handy in many cases. This is next door to the tool-post, and a word concerning it may not be out of place. Every machinist knows the defects of the ordinary tool-post like Fig. 3. It's a wabbly concern at best and has caused no little profanity by letting the tool gouge into work on the last

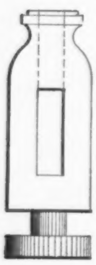


FIG. 3.

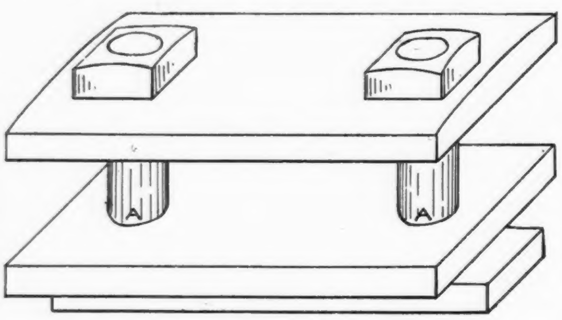


FIG. 4.

cut. Fig. 4 isn't a beauty, to be sure, but it holds the tool better, and the writer made one a number of years ago which has given good satisfaction. The lower bar is just the size of the T slot and has the studs A A screwed into it. The large bottom plate is half an inch thick and fits loosely over the studs, resting on and just covering the top of the tool block. The top plate is the same size as the bottom one, but is tapered toward the edges. Coil springs around each stud keep the top plate from falling when not in use. This holds the tool very firmly and supports it out pretty well to the cutting edge, making, all told, a very serviceable arrangement.

One of the experimental experts of the factory was testing a small jet apparatus the other day, and they had difficulty in opening and closing the valves gradually enough. The valves used (and they were quite small ones, too) would close so suddenly that the jet would break. The engineer suggested using a small cock, but this was little better, if any, and finally one of the apprentices made the rig shown in Fig. 5. This is really a special cock with side outlet (which was for convenience in this case, and does not affect the gradual opening in the least), with the admission edge of the plug filed off on an angle as shown at *a a*, Fig. 5. It will be readily seen that this will close the opening very gradually, and that a small opening remains during quite a movement of the plug. In other words it shears it off gradually instead of chopping it off suddenly. It solved the problem, anyhow.

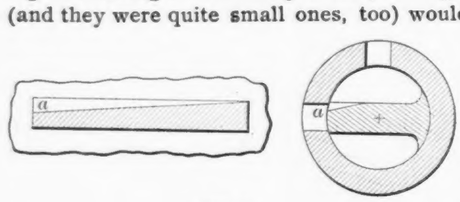


FIG. 5.

There are generally two or three ways in which a job can be done, and one way is likely to be more economical than the others. The engine department of the shop where I hang out makes their connecting-rod ends like Fig. 6, and the hole has always been worked out by drilling around, as shown at the left, then slotting the sides of the hole smooth. Sometimes every alternate hole is plugged with hard wood and the remaining walls then drilled out. This is an old scheme, however.

The foreman of that shop went off on a vacation last summer, and wandered into a locomotive shop while away. He saw them working out rod ends there, and when he returned he changed the methods on that job. He was handicapped by having a

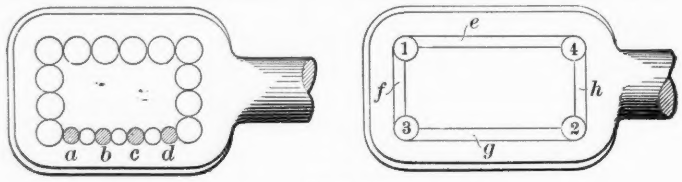


FIG. 6.

slotter which had both dyspepsia and lumbago, was weak front and back, and in fact hadn't any surplus strength anywhere. But he braced things up as best he could and managed to do a creditable job on the plan shown at the right. He drills four holes, 1, 2, 3 and 4, at the corners, starts his slotter with a narrow tool and slots from one to the other. This finishes the slotting at one operation. In the railroad shops they sometimes drill but two holes, 1, 2 or 3, 4, and slot both ways from 1 to corners 3 and 4, and from 2 to the same corners.

* * *

ILER'S SPRINGS.

GLENN FRANKSON.

The last time I was at Iler's little shop he was bothered with some springs he was making, and like many other things, Iler wasn't bothered with the mere making of the springs, but it was keeping them in any kind of respectable shape, while hardening and tempering, was what troubled him. These springs were something like the springs used in a Schaeffer & Bradenburg steam gauge, only more so—larger in diameter, more and deeper corrugations and thinner metal. Remembering that the springs were circular, they were something as represented in Fig. 1; not just like it, but near enough so for present purposes.

Every machinist will understand that the springs—there were several of them, with the prospect of more to come—could be spun up with the greatest of ease, and in a way too obvious to mention. The spring were spun all right, but when it came to hardening them, Iler said you might just as well try to harden a rainbow and have it come out straight.

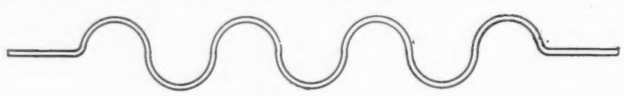


FIG. 1

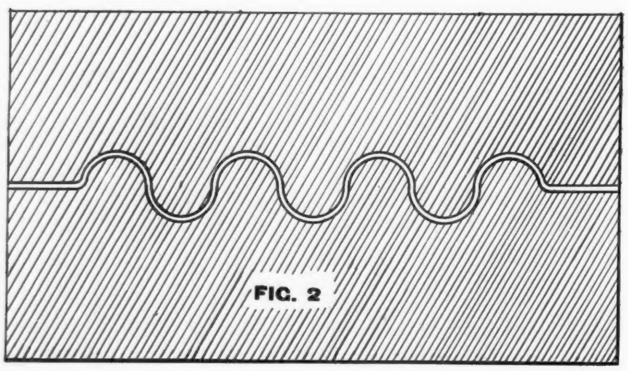


FIG. 2

If he had been acquainted with the process of tempering the gauge springs referred to—which I am sure I am not—he might not have been troubled. However, he got out of, or into, the scrape pretty well, as it was. He took two solid pieces of cast iron, Fig. 2, and turned a face of each so they would just come together nicely, with a spring between them, which I hope will be understood better than I have taken time to indicate it in the sketch. Placing these convenient to the fire, he smeared their faces with very thick oil, heated a spring, placed it on one of the pieces, on that the other piece, and on that a considerable weight.

It is hardly necessary to say that if all this, the getting together the two parts of Fig. 2 with the spring between them, had

occupied as much time as it does to read about it, the success would have been doubtful. The point is that the springs were hardened and kept true, remaining true when blazed to temper. If one had millions of these springs to temper he would doubtless devise a plan of doing it much superior to this. With the few he had to do, it seemed to fit in with Iler's purposes very well. Perhaps this principle could be applied—likely enough is—to delicate springs of other than a circular form.

* * *

MARINE ENGINE DESIGNS.—I.

WM. BURLINGHAM.

Many of these notes are no doubt applicable to other work than marine engine design; but in this article it is considered better to call attention to facts that ought to be observed by all draftsmen in the design of marine engines. The methods of finding the required sizes of engines and the most suitable types for certain work have not been touched upon; merely such points as the engineering works rarely discuss, yet which are a bane and a source of much anxiety to the striving draftsman.

It is impossible to lay too much stress upon the necessity for extreme care and accuracy in this designing. For in marine work the lives of hundreds of people may be placed in jeopardy by the lack of attention to small details that in land engine work would mean but the closing of a mill or factory for a few days. The designer must constantly bear in mind that the engine is to be run by men who are so hemmed in that it is practically impossible in case of accident for them to escape the results of his carelessness, without severe injury and often loss of life.

It is necessary that the engine be so constructed as to afford facilities for rapid overhauling, and efficient means should be provided for moving all heavy parts. All safety, stop and throttle valves must be accessible for quick operation and located in such places that the heat will not overcome the men in operating them. Careful attention should be given to the lead of the steam and exhaust pipes, avoiding all short bends and any method of fastening that would bring undue strain upon the pipes while under expansion. "U" bends or expansion points should be inserted in all lengths of pipes that are secured against movement at the ends, many accidents having been caused by neglecting this detail, from the consequent rupture of pipe. Large drains should be placed at all low places, to carry off the water of condensation; the hammer caused by this entrapped water often creating a pressure of from two to three thousand pounds per square inch in the pipes. By large drains is meant very large ones, as the prevalent custom is to insert absurdly small ones, and trust that no accident will happen.

Place drains in both steam and exhaust pipes and do *not* be afraid to use large ones. The United States Bureau of Steam Engineering have a very good rule: "Use one square inch area of drain for eight thousand cubic inches of steam pipe for diameter of drains between ¾ inch and 2 inches."

In no case use a drain less than three-quarters of an inch internal diameter. There should be slip-joints at all bulkheads, and if brass flanges are used care must be taken that they are not arranged with the bulkhead between, as cases are frequent in which galvanic action has eaten holes entirely through heavy copper pipe.

Valve hand-wheels are made large in diameter, and where liable to heat should be covered with some non-conducting material to protect the hands. All reciprocating parts of the engine must be fitted with double nuts, preferably of the same thickness, thus allowing either to be screwed on first. These nuts must be secured by split pins. In fact split pins are a constant necessity and should be used on every bolt subject to vibration—a marine engine undergoes so many different shocks and vibrations that it is impossible to prevent the nuts from working loose unless some such means are used.

What is known as "fouling" constitutes one of the greatest troubles that arise to worry the designer, and it is one of the most difficult things to forsee or prevent. The majority of the working parts of an engine are in constant motion, and though they may clear in the still position, they are quite likely to foul when moving, if not in the go-ahead position then in the go-astern. Experience seems to point out the following places as some of those that will bear the closest watching.

The crank-pin end of the connecting rod is apt to foul the bedplate and the inner bottom of the ship; the rod itself with the lower corner of the cross-head guide, and the cross-head pins against the gland nuts of the piston-rod packing; the eccentric straps and the inner bottom; the ends of the links against the reversing arm when thrown into backing gear, and the suspension rods with the engine columns. The valve-stem nuts have a habit of fouling the bonnets or the upper end of the valve-stem stuffing-boxes.

The clearances between the piston and the cylinder heads should be ample, yet as small as possible; the clearance at the crank end of the cylinder to allow take-up, for the wear of the crank and cross-head pin brasses.

The piston itself should be turned one-sixteenth to one-eighth smaller in diameter than the cylinder bore, thus enabling the piston rings to adjust themselves to the inequalities of the cylinder and to a slight degree the lack of alignment in the engine.

Be careful that the oil gear, water service and throttle-valve gear are well clear of each other and of the moving parts of the engine; they should be so situated as to admit of a clear entrance into the interior of the engine. Ample room must be given for feeling the main bearings while the engine is in motion. Give plenty of room for the use of wrenches in setting the nuts, as it is a barbarous method to use a hammer and cold chisel, yet how often it is done.

Castings do not always come to the sizes expected, and allowance should be made in all work for this discrepancy. Make provision for a slight derangement of positions of all brackets and bosses. When bolts are not fitted, the holes should be drilled slightly larger in diameter than the bolt or stud. It is very often cheaper and better to use dowels than fitted bolts. In case the air pump is worked from the main engine be careful that the air pump beams clear the top of the condenser at the extreme position of their swing.

These are some of the close places that it is necessary to guard against, and there is hardly a draftsman who cannot call to mind some of the slips and the quarter of an hour that follows. In future articles attention will be directed more particularly to the clearances necessary for each particular part.

Iron or steel studs tapped into brass should not penetrate into the steam or water space, as rapid destruction will follow from galvanic action. It is better for studs or bolts tapped through boiler shells to have the nut or head on the inside of boiler, although sometimes fitted bolts are used in ordinary merchant work. Do not use less than a ¾ inch bolt or stud, as a wrench in unskillful hands is liable to cause an initial stress actually greater than that due to the normal load on the bolt. Set screws, where used constantly, are better with large square heads, well case-hardened.

When a square nut is used it should be of same size as some standard hexagonal nut over flats, otherwise much time may be lost seeking for a suitable wrench. All bolt heads and nuts should be standard, and if it is necessary to use a large bolt with a small head, make it a standard of some smaller size. Packing gland studs are better larger than actually needed for strength, as they are constantly being set up, and if the gland leaks, it is impossible to foretell what strain will be brought to bear upon them by an engineer with a big wrench when in a big hurry.

All the working parts of the engine should be of a fairly good, but not a dead fit, and the main pins, as cross-head pins and air pump connecting-rod pins, are better flatted on their sides sufficiently to allow an ample space for oil. End play is necessary for the crank-pin end of connecting-rod and the crank-shaft in the main bearings, so they will not bind when heated and will allow for the wear on the thrust collars and for a slight movement of the cylinders in a fore and aft direction.

Each piece of the engine should be designed with equal care that it may be easily moulded, cast and machined; a very slight difference in design may greatly affect the cost and save much annoyance in the shops.

Bolt holes should be located in such positions as to allow the use of drilling machines or at least of a ratchet drill. It is often possible to design the intimate parts of an engine in such a manner as to enable them to be set up before the main engine is erected.

Steel castings are better if made simply, without intricate cores, and with large fillets and few ribs. The shrinkage will vary to a considerable degree, depending upon the way in which the casting is moulded. If there are several large pieces of similar shape it is better to measure the first casting and then make the neces-

sary alterations to the pattern. Sections of cast steel bed plates should most certainly be checked in this manner, even if the metal is of equal thickness with simple cores; iron castings are better with small fillets. In any case, casting work should be simplified as much as possible.

Cylinder ports must be free and unobstructed, ample in area, with the walls well stayed, as nothing is more terrifying than to see some of the walls of large ports working up and down like a pair of bellows. It is well, and in fact necessary, to have everything as light as possible in a marine engine, but it takes a good deal of judgment sometimes to tell where to lighten up, and if one is doubtful it is better to err on the safe side.

Indicator bosses must allow for a straight lead from the indicator to the point of attachment of the string and be clear of all steam pipes, as it is most fatiguing to lean over a hot steam pipe in taking cards; the easier it is to get cards the oftener the engineer will take them, to the consequent advantage of the owner, and often the speed of the ship.

Be certain you have all the necessary pads and bosses upon the cylinders and condenser. For instance, on the cylinder you will need bosses for indicators, drains, safety valves, relief valves, receiver steam, lifting bolts, peep holes for valves, pads for stays, valve-stem guides, and often man-holes, and jacket steam and drains.

The condenser will require connections for air cocks, drain cocks, jet injection, vapor pipe, salt feed, soda spray, snifting valve, air pump, boiling-out nozzle, main injection, man-holes, hand-holes, bosses inside for division plates, baffling plates and outside, in many cases, for air-pump seatings and guides depending in a great measure upon the style of engine. In case the condenser forms a part of the engine framing it must be well ribbed not only to withstand the outside pressure, but to enable it to resist successfully the strains due to the working of the engine.

The engine hatches should be of sufficient dimensions to allow the largest piece of the machinery to pass through without incurring the necessity of tearing out a portion of the ship.

The intermediate shafting is usually made in such lengths as to admit of its being taken out through the engine room, without disturbing the engine. The thrust-bearing surface should be ample with collars of medium diameter, as with large collars the difference in diameter of outside and next the shaft would be so great as to cause heating from friction due to the difference in speed of the wearing surfaces at these points.

The steady bearings should be of ample length and numerous enough to keep the shafting perfectly in line. Make the stem tube and bracket bearings long with good provision for water circulation.

The lubrication of an engine is most important, and large oil-holes should be provided in all working parts, the oil pipes should be large, free from pockets and easy of access. It seems to be the general concensus of opinion, that very little oil is required for the cylinders; that which is supplied to them is carried through to the feed-water, occasioning a great deal of trouble in the boiler, and as it is almost impossible to remove it from the feed, it is better not to allow any more than absolutely necessary to enter the cylinders. Tallow cups should be provided for the main bearings, so secured as to allow of quick removal.

The water service should be carried to all parts of the engine that are liable to heat, and to each thrust and steady bearing, of liberal size, with provision made to direct the waste water to the bilge, leaving the crank pits free.

A packing space of from one to one and a quarter inches is necessary under the main engine, thrust-block, sole plate and steady bearings, with plenty of bolts to hold the engine firmly to its seating. Every piece of the engine should be carefully considered; calculate the required dimensions from the sizes of successful engines, remembering that if it is of a different type your work may have to be modified to suit your case. Also that the piece you are designing does not stand by itself, but in conjunction with many others, and should be considered in connection with these to make an harmonious whole. An awkward engine, if I may be allowed the expression, though it may do its work well, will not sell as readily as one of good design. By good design is not meant highly polished parts, but a seeming fitness of each part to the other. It is almost impossible for any one to make an engine that will not turn over, yet to build an economical one is a matter that requires much experience and thought. Those engines that break down every trip because of a small bolt or rod giving way, are unfortunately too numerous, and one must be sure not to take that kind for a guide.

Be careful in selection of data, as poor data is worse than none at all. Use none but that which you know is absolutely accurate, otherwise you may be at a loss to know why your work did not turn out as well as was expected.

A marine engine is at work night and day, with no chance of stoppage for repairs, it may be for two or three weeks and then only for a few hours. It has to propel a ship carrying hundreds of people and thousands of dollars worth of cargo. A weak spot in the engine may mean the loss of these lives and the goods—a loss caused perhaps by a moment's carelessness on the part of the draftsman.

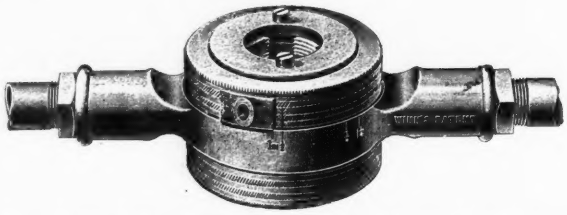
It is hardly fair to depend upon the chief draftsman to note all these small mistakes, as he has other work to do and this is left to you. The large errors will be observed and corrected; but the small ones, those that come back from the pattern and machine shop, causing worry and anxiety, are all under the draftsman's personal control, and should be sharply looked after. A neat looking drawing is undoubtedly to be desired, but one in which the mistakes are left out is the one that has the most influence on the salary.

It is hard to impress the necessity of strict accuracy, for inaccuracy is the most human of failings—we are all subject to it—and constant watchfulness is necessary to avoid mistakes. In subsequent articles the design of the more important pieces of the engine will be treated in detail.

* * *

ADJUSTABLE PIPE DIE.

The accompanying pipe die is taken from one of our foreign exchanges, and is evidently novel in some respects. The various sizes are evidently obtained by moving the index plate, shown by arrow to divisions shown, namely, ½ inch, ¾ inch and 1¼ inch.



It is not quite plain how the 1¼ inch is obtained, for the Whitworth standard threads are ½ inch 14, ¾ inch 14 and 1¼ inch 11 to the inch. The top ring, held down by the screws shown, probably allows of a quick change of dies for any desired pitch of of thread, for use on bolts instead of pipes.

* * *

SELF-LUBRICATING BEARINGS.

What appears to be a new and useful invention is the bearing being made and introduced by Mr. J. W. Haley, Milford, Me. The invention consists of a compound of metal and graphite made in such a way as to hold the graphite in solution, which is said to have never been accomplished before. All the metals used will fuse at a much lower temperature than will vitrify glass, which requires 4 000 degrees Fahr. These metals are thoroughly mixed while in a powdered form, and combine before the glass becomes liquid. They are then pressed into the journal, make a hard and self-lubricating bearing, and one which cannot be melted out by any friction that could occur, as it will stand a red heat.

Glass alone makes a journal that will run with less oil than babbitt, but it is too brittle. Mr. Haley makes his journal of glass, lead and graphite, which makes it self-lubricating. For light shafting he uses a little antimony, while for large shafting with its increased pressure, he adds powdered brass and aluminum. Mr. Haley sends copies of several letters from shops in his vicinity, testifying to the successful running of these journals. In one instance a 1½ inch shaft is running 3 200 revolutions per minute, without undue heating. The box is 6 inches long in this case. Another letter states that boxes of the same dimensions have been running 3 000 revolutions per minute for 36 days and 9 hours (when the letter was written), and that they have remained practically cold with no appreciable wear. It looks as though Mr. Haley was on the right track, and we trust that these results can be borne out in everyday practice. It would also be interesting to know the power consumed by these as compared with a well lubricated bearing.

SOME PROVIDENCE IDEAS.

Warren E. Willis.

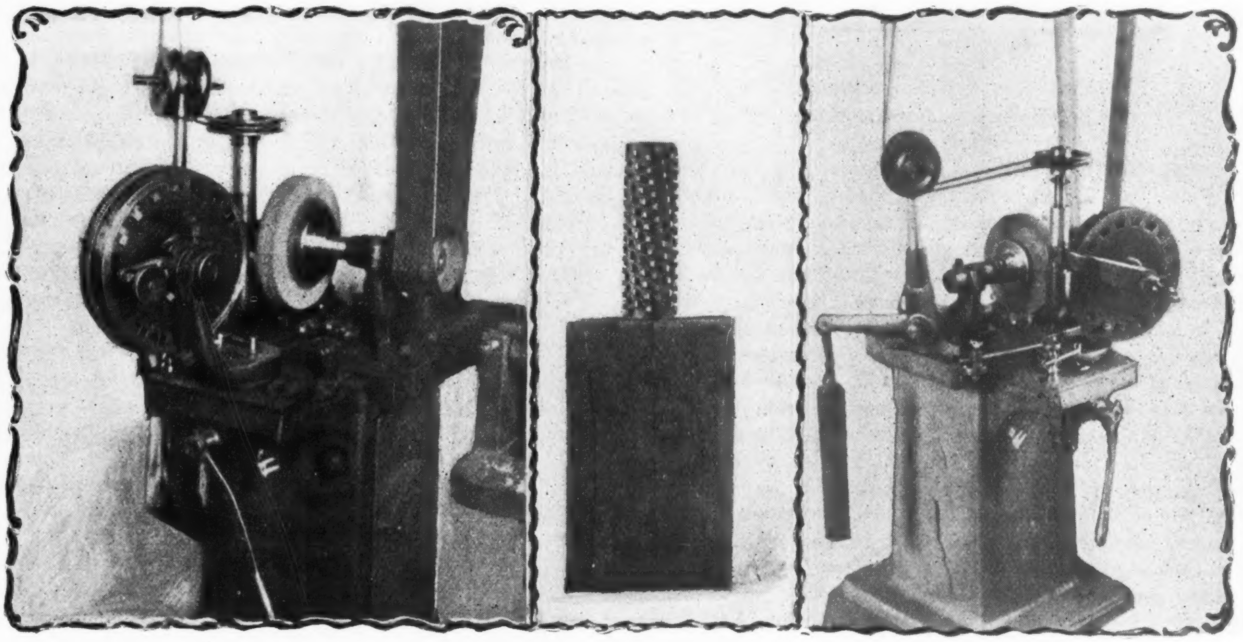
The cutter illustrated has been in use for several years on iron castings, just as it came from the foundry, taking a cut from one-eighth of an inch deep; the only labor expended thereon has been an occasional grinding.

The teeth are placed in rows, spirally, something after the well-known Ingersoll mill, although the construction is entirely different.

An ordinary wrought iron pipe, about four inches in diameter, mounted on the centers of a universal milling machine, was drilled and broached to receive the cutters, which were bits of five-eighths square Mushet steel, broken off approximately 1½ inches long, from the ordinary commercial bar.

After being inserted in the pipe an even length, about half an inch remaining out, the whole was taken to the brass foundry, a core arranged in the center and melted brass poured therein.

The teeth were found to be firmly held while the brass gave sufficient backing; after truing up, boring the hole to finish size and grinding, the job was complete.



MILLING CUTTER AND GRINDER.

Another illustration represents an unpatented contrivance for grinding large face mills, and is the product of the thought and ingenuity of Mr. J. A. Gardner, to whom many of the peculiar and valuable contrivances for special work at the Armington & Sims Engine Works are attributable.

As there are here employed several heavy milling machines, of the Newton type, such a grinder is quite indispensible.

This arrangement is so clearly shown that but few words are necessary to describe its action.

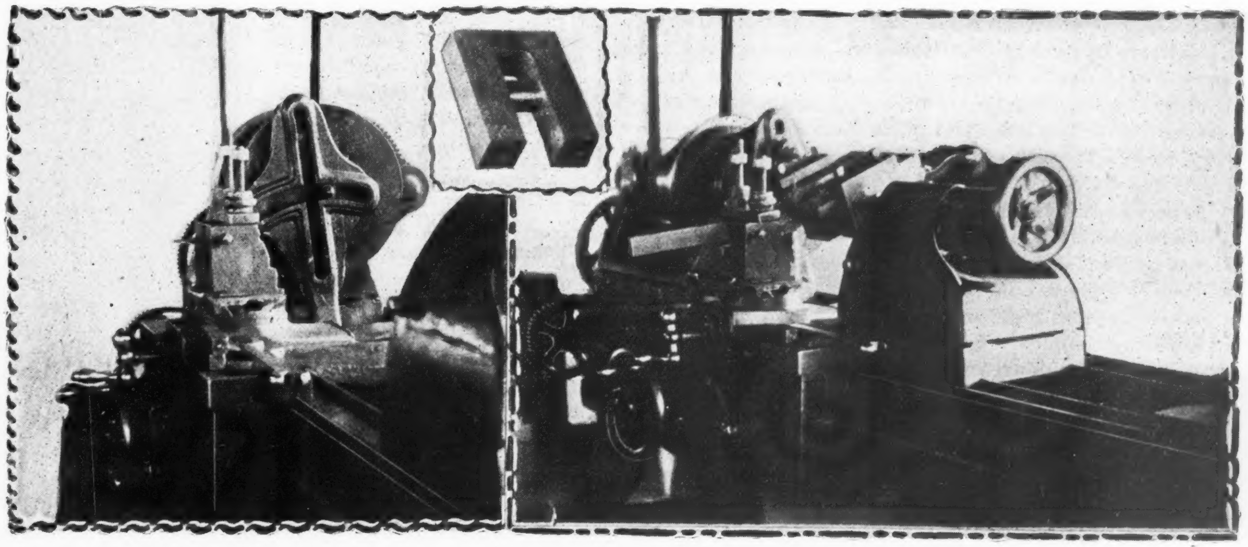
The drum or false head is provided with receiving slots or apertures for the whole number of teeth in a cutter; these are held in the false head at such an angle that the clearance on the cutting edge and front is obtained alike on each.

Means for revolving this head are shown, consisting of the worm and gear, run by the independent flexible belt.

The entire surface of the emery wheel is used by moving the fixture by means of the lever at the bottom; corners having more or less of a round, as desired, are obtained by swinging the fixture on a movable pivot at the base upon which the whole affair rests, the whole operation being automatically performed.

A crosshead (the one shown in March as a problem) and means for turning it, are also shown. This piece is a casting, shaped like the letter "H", with a brace cast across the top, it is a somewhat difficult matter to turn the pin, which is likewise cast solid with it, that is, with no special rigging.

In this case, a casting, shown in front of the face plate, is pivoted to the lower part of the head of the lathe, in such a manner that it can swing freely thereon, motion being imparted to it by a block sliding in the perpendicular slot, the said block being upon a stud affixed to the face plate.



TURNING A CROSSHEAD.

The semi-circular slot, crossing the perpendicular one, is only for the purpose of clearing the lathe center, as the fixture is oscillated by the revolutions of the lathe.

It will now be seen that if a crosshead, or other work, be placed

in a suitable vise or shoe, the centers of the work to be turned being coincident with the centers of the lathe, and this work-holding fixture be attached to the oscillating part, a reciprocating forward and backward motion will be imparted thereto; and that if a tool be applied, having an arrangement somewhat similar to a planer clapper box, that is, so as to relieve itself on the backward stroke, that one half of the work can be readily turned; the other half can be got at without any change by using a hook tool having a similar arrangement.

As a matter of convenience the work is usually planed on the sides, almost to size, before being placed in the fixture.

OBITUARY.

JOHN HALDEMAN COOPER.

Mr. John H. Cooper died at his home, 4724 Springfield avenue, Philadelphia, May 9, 1897, of heart failure.

Mr. Cooper was born in Columbia, Lancaster County, Pennsylvania, February 24, 1828 He was a member of the American Society of Mechanical Engineers, and for many years prior to his decease occupied a prominent position in connection with engineering science, and both by his writings and his works has eft an ineffaceable imprint upon the time in which he lived.

Mr. Samuel Wright, of Columbia, writes me as follows:

"I can say that he was a school-fellow, but scarcely a play-fellow. His play-ground was a small outhouse fitted up as a carpenter's shop on the rear of the house lot, where he devised and constructed whatever utensil or machine his ingenious mind suggested. One production of his handicraft was a practicable locomotive engine, entirely of wood. Later, in connection with another boy of his own turn and skill, with improvised tools and machinery, he built a complete steam-engine, which drove by side-wheels a good sized skiff, which carried safely boy, crew and passengers.

"In school I remember him as a serious, studious pupil, probably a specialist, but from my occasional intercourse in after life, I infer that he was an attentive general student.

"In those days boys of his class here (in Columbia) attended private rather than public schools, which were fairly preparatory to boarding schools.

"While he was in no wise a a shy or morose boy, he was unusually serious and earnest; and I have no doubt that his mechanical pursuits were to him what games and sport are to the average lad. He picked up carpentering in the little shop above mentioned and also gained some instruction in the shop of his uncle, Israel Cooper, a builder of that day. Mr. Cooper left Columbia before his majority, for Baltimore."

During 1849 Mr. Cooper was at Benjamin Hallowell's school in Alexandria, Virginia, and commenced his profession as a draftsman with Charles Reeder, an engine builder in Baltimore, in 1850. From Baltimore he went to Norristown, Pa., entering the employ of Messrs. West & Newbold, builders of Cornish pumping engines, about 1853. During 1857 he commenced the building of gas regulators, invented by him. He occupied an office in common with C. Newbold Trump and W. Barnet Le Van at No. 114 North 7th street, Philadelphia.

In 1860 he was employed by H. P. M. Birkenbine, as a draftsman in the water department. In 1862 he was in the employ of W. Barnet Le Van, as draftsman. In 1863 he went into the employ of the I. P. Morris Company, having charge of two monitors being built at Chester, Pa., for the United States Government.

Mr. Cooper was employed by Mr. Jacob Naylor, of the People's Works, Front and Girard avenue, Philadelphia, Pa., in 1864, where he remained until December, 1881. While here he designed and built the only compound engine at the Centennial. Then his health failed and he went to California, remaining there three years.

In 1884 the Mare Island Navy Yard, near San Francisco, required pumps to empty a new dry dock of its seven to nine million gallons of water within the limit of time necessary to safely secure a vessel within the same, and a suitably proportioned pumping mechanism was necessary. Mr. Cooper was induced to return to Philadelphia by the Southwark Foundry and Machine Company to design a pair of centrifugal pumps for this work, to have an aggregate average discharge of 80 000 gallons per minute, and a drainage pump with an average delivery of 2 000 gallons per minute, together with the necessary pipes and valves to connect them with the suction wells of the dock, and to the discharge culvert communicating with the river, including propelling engines, bed-plates for supporting them, and full equipment for operating same. No general plans or details whatever were furnished; the plant was to be delivered and erected in a house to be prepared by the Government, beside the dock, to which also steam would be conveyed from boilers furnished by the department. When completely erected by the contractors, the plant was to be tested by a committee of experts appointed by the commandant of the yard. The plant was furnished and erected according to Mr. Cooper's design, and proved to be a great success.

He then acted as a consulting engineer, and at the time of his death was in charge of the Worthington Self Cooling Condenser in this city.

Mr. Cooper was one of the managers of the Franklin Institute from 1870 to 1873; he was also a member of the Committee of Science and Art, up to the time of his death. He had made a special study of belting, and his book on this subject is considered a standard authority.

Mr. Cooper was a self-contained, undemonstrative man, but always genial in his manners, simple and unaffected, frugal in his personal economy, temperate in his habits—almost to abstemiousness—a lover of books for what they contained, and a persistent collector of facts. He was indefatigable, industrious, and his inclination for work continued to the end of his days.

The world is a gainer that he has lived, and engineering has a higher status because of his integrity, his fidelity, his self-respect and his sturdy manliness. Peace be to his ashes! Mr. Cooper had two children, both of whom died before his decease. His wife alone survives him.

On Monday, May 3 inst., prior to his death, he was in Washington, D. C., attending to his business, and on Sunday, the 9th inst., was stricken with heart failure.

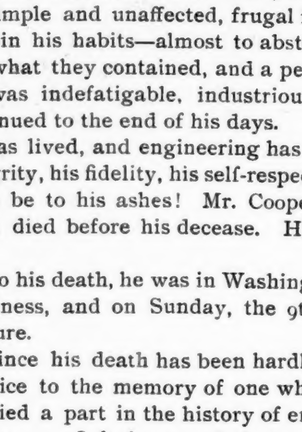
The brief time at my disposal since his death has been hardly sufficient to enable me to do justice to the memory of one who has played so prominent and varied a part in the history of engineering science as has Mr. Cooper. I feel assured that my shortcomings will not affect his merits, from which they cannot possibly detract, nor will my deficiencies impair the brightness of the memory of one whom to know was to appreciate and respect, and whose character and attainments can cease to be admired only when they cease to be remembered.

Philadelphia, May 19, 1897, W. BARNET LE VAN.

* * *

AN OLD MILLING MACHINE.

The accompanying illustration is the result of poor light and lack of contrast, and is only used on account of its representing a type of milling machine not often seen now. It was found in an old shop in Clinton, Mass., where it had probably been at work for forty years. The driving or cutter head moves vertically while the work remains stationary, as in the old Pond machines, and recalls anything but pleasant recollections of work done on one of the last-named milling machines. This one, however, has the cutter spindle supported at the outer end, an improvement over the Pond. At the time of the photograph the chuck on the table was holding small bolts while the straddle mills finished the sides of the head. The general light appearance gives good evidence that its capacity for smooth work is decidedly limited.



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MR. BOOKER T. WASHINGTON, principal of the Tuskegee Normal and Industrial Institute, Tuskegee, Ala., is soliciting donations of machinery for the trade schools of the Institute. As we believe the best way to aid any class of citizens is to teach them to help themselves and so become independent, we feel that schools of this kind are a good thing and hope to see this one continue its growth. The enrollment last year was 1 008 of both sexes, which is divided among twenty-five industries. While the returns from a gift of this kind are apt to be slow and indirect, there must be some returns from the fact of the students becoming acquainted with the tools used.

BRASS WORKING TOOLS.—2.

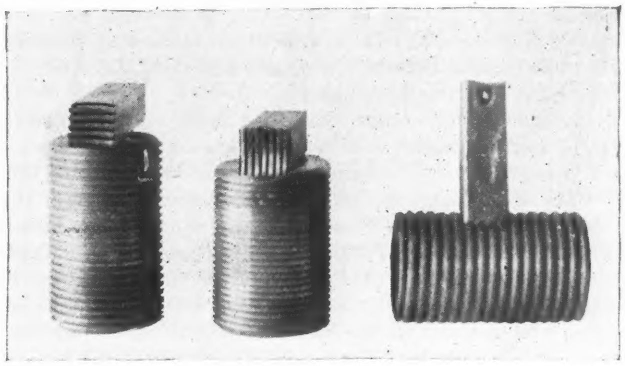
LATHE TOOLS, HAND TOOLS, AND SLIDE-REST TOOLS.

The fox, or chasing arrangement of a fox lathe, always interests a machinist. The threads a fox lathe is required to chase are always short, rarely over an inch or two inches at most; of course I'm speaking of regular work, such as valve parts. Consequently a long lead screw would be in the way and an unnecessary expense. Instead of this, short cylinders of cast-iron or steel, the former for fairly coarse threads and the latter for fine threads, are bored to fit a stud on the machine, either a sleeve on an extension of the back gear spindle, or an independent stud on end of lathe, (the latter is preferable), and are used as leaders. Threads are cut on these to lead the chasing-bar at the right pitch and in the desired direction, either right or left hand. As usually arranged, the stud revolves half as fast as the lathe spindle, and consequently the pitch of the leaders must be twice as great as the desired thread, *i. e.*, a leader for a 14-thread must be 7-pitch, and moreover must be reversed in direction from the desired thread, as the stud revolves opposite to the spindle.

The doubling of pitch is an advantage and is done purposely to avoid the necessity of cutting extremely fine pitches on leaders, as the followers would wear rapidly. As 27-pitch threads are used on small pipe fittings, a 13½-pitch leader must be made; much finer than this would be impractical.

Followers are usually of brass, about 1 inch square and 4 or 5 inches long, although some of the later lathes have a revolving arrangement which carries 4 or 6 different pitch followers. For leaders, about 2½ to 2¾ inches in diameter, and probably 3½ to 4 inches long on the average. The expense of these account for the tendency to use babbit, even if they do wear out much sooner.

This prompted the writer to make a device like Fig. 5, which is



FOX LATHE LEADERS (OR HUBS) AND FOLLOWERS.

simply a piece of 2-inch machine steel, about 10 inches long, with a round hole through it, about the center, to take ⅜ inch square steel and good deep centers in the end. A cone-pointed screw at right angles to hole, and located so as to bear in a shallow V groove *a*, made in the side of cutter, as seen in the cutters shown above the bar. Taking a piece of ⅜ inch square steel

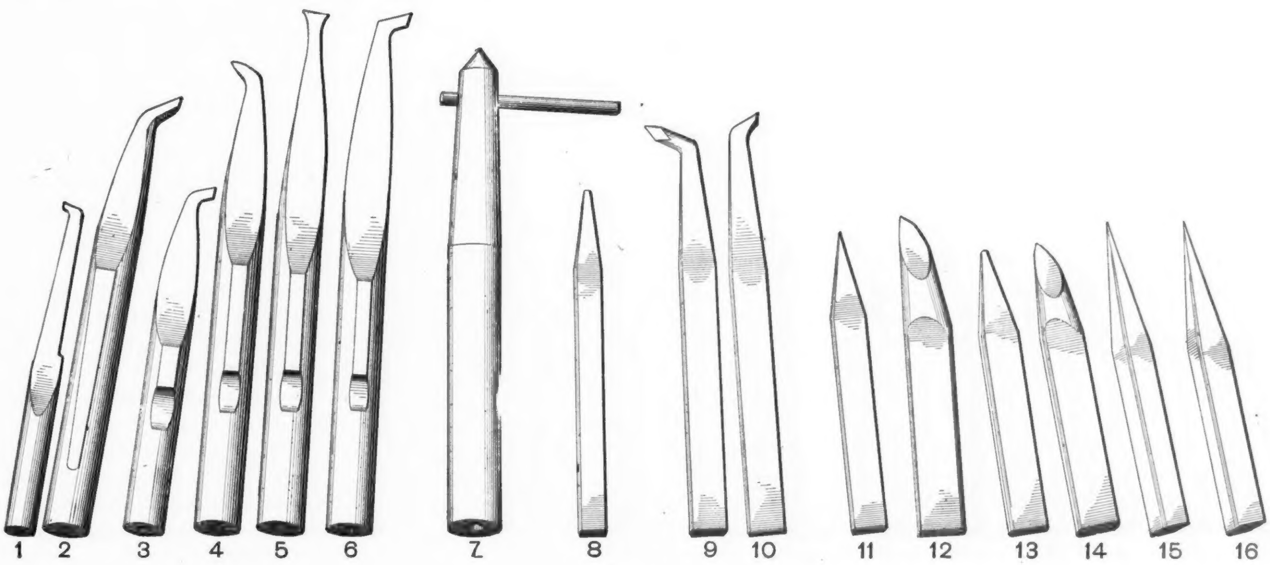


FIG. 6.

coarse pitches, the followers are sometimes bored in the end, also a side hole for pouring, and the threads poured of babbit metal into the threads of leader. This is done by making a clay dam around the follower as it rests on leader and pouring in the hole on side. I have seen threads as fine as 14 to the inch, run this way, but do not advise it; a brass toothed leader is preferable, as there is considerable more strain on these than is imagined, for the chasing head must be held down firmly at times, which makes

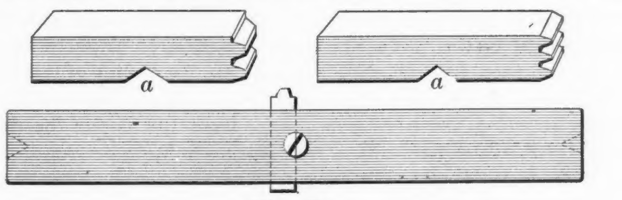


Fig. 5

considerable friction in the bearing between shears and chasing head. Then, the wear and tear due to the leader revolving under the follower before catching the thread, is considerable and soon wears out the babbit teeth on any but the coarser sizes, where there is considerable body of metal to withstand it.

The usual way of cutting brass followers is to have a steel hob, which is first cousin to a hob-tap, and is used in the same way. The follower is held in tool-post of lathe and fed by lead screw while the hob revolves between the lathe centers. These hobs are necessarily expensive as they must be the diameter of the

about 2½ inches long, and filing the groove so that the screw will hold it firmly and square with bar, put the whole thing in lathe and turn the end to diameter of leader. Then cut a thread of the desired pitch and shape in the end of this piece of steel, as shown by sketch. The thread generally used is what is commonly called a "bastard" or "half V," as the follower drops into place more readily than if it were square or nearly so.

On coarse threads there will be but one tooth on your cutter, as seen in the bar, but this will answer nicely. The other cutters merely show different pitches. After backing these off, just as you do a tap, and tempering the end much as you do a lathe or thread tool, place a cutter in the bar, put a follower blank in the tool post and go ahead.

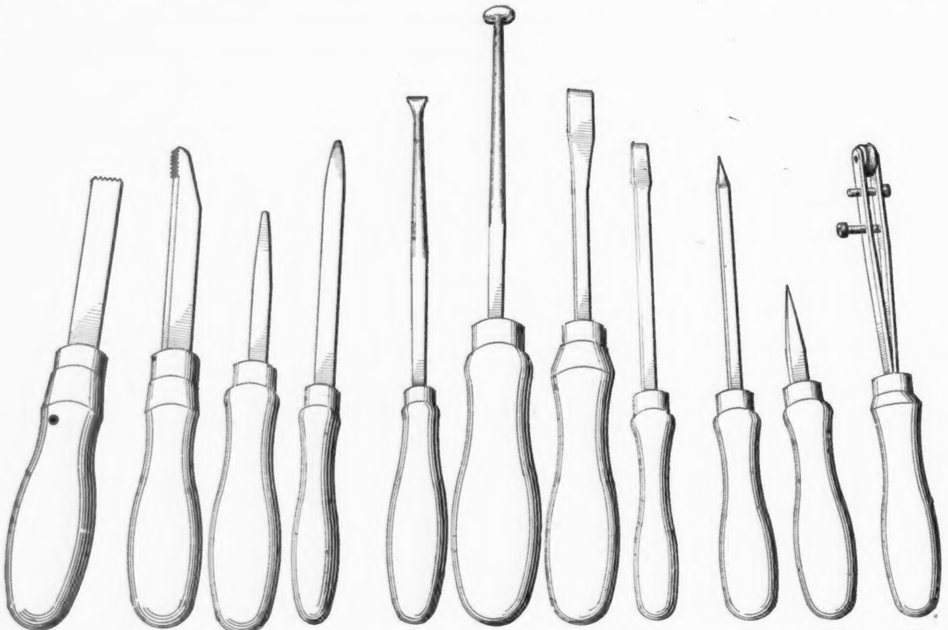
By using the lathe feed you can use the cutter to turn out the end of the follower to fit the leader, then throw in your lead screw for the desired pitch and proceed exactly as in chasing a thread. This makes a very cheap way of cutting followers, as the bar shown, and a set of cutters for the sizes you'll need, can be made for about the price of one steel hob.

Fig. 6 gives a group of back-head and slide-rest tools, most of which are faithful reproductions of the photograph; a few, however, were probably not quite clear to the engraver, and he has fixed them to suit himself. Numbers 1 to 6 are back-head tools. These are usually made of octagon steel, which is first turned to the taper of the back head spindle and then forged to the desired shape on the cutting end. At times sockets are provided; these are directly in the spindle and are held by set screw on top.

They are used for inside or outside turning, according to bend of cutting point, and do a large amount of quite accurate work in the hands of an expert fox lathe hand. By the skillful combination of the cross and lengthwise movements of the back-head and spindle, a good man can follow the outline of about any irregular shaped casting he can swing in the lathe, and though a tool will occasionally catch and break from a false move of either hand, these occasions are rare, and usually subject a man to the jokes of his companions.

No. 7 is a driving center similar to those used in some kinds of light machine work. Nos. 9 and 10 are chasing tools, and are held in the tool post of chasing head, as shown last month in Fig. 1. They are adjusted so that the cutting point is at right angles to lathe spindles, which of course, makes the thread square with the work. Some use a chasing tool in various forms, having several teeth, but the writer has seen the most and best work done with the single point tool, when it is well tempered, correctly ground and set, and in the hands of a man who knew how to use it. It is not conducive to familiarity with anyone standing behind the lathe, as it shoots a stream of hot brass chips that would make a gattling gun blush.

The other tools, number 8 and 11 to 16, are slide-rest tools, which are simply pieces of flat steel, about 3/8 by 3/4 inches and 5 inches long, forged out quite thin, with good clearance on both sides and end, but no top rake. The artist has forged them into various shapes of his own, but the idea is there. The cutting edge is practically even with top of tool, any top rake makes it dig in and raise Cain, generally. If you don't believe it, just try cutting brass at high speed with a good, sharp diamond-point tool and note the result, especially where the work is held in a master chuck as shown in Fig. 3 last month, for this kind of work is very rarely turned between centers.



1 2 3 4 5 6 7 8 9 10 11

FIG. 7.

Fig. 7 shows quite a collection of hand tools. Beginning with 1 and 2, which are outside and inside hand chasers, respectively, for sizing or going over threads, used on repair work, and at times starting and chasing a complete thread; these instances are few nowadays, however, and many a good fox lathe man couldn't chase a thread by hand to save his life—doesn't have to now. Numbers 3 and 4 are roughing tools, for use where it doesn't pay to put the slide-rest in place, and you can trust the piece-worker to know when it *does* pay. Numbers 7 and 8 are flat finishing tools, or planishers, as some call them. They are held flat on hand-rest for most work, though occasionally used similar to a patternmaker's chisel on top of work, but for light finishing work only. Tools 9 and 10 are cutting-off tools, are ground quite thin, but left fairly deep, to support cutting edge as much as possible. Number 11 is a milling or knurling tool, or more properly, a "rolling" tool. The wheels or knurls, are hardened steel disks, with various serrations, figures, dots, etc., cut in the edge. These are forced against the work in the desired places to roughen it, either plainly for the purpose of giving a better hold for the hand in unscrewing, as on some kinds of nozzles or salt cellars, or for decorative purposes. Some of these contain quite elaborate designs of flowers, etc., which are literally forced into the metal. This kind of work has gone by, however, and is rarely used now. The plain ones only, are now used, and for useful purposes almost entirely. The days of fancy brass work, without some semblance of usefulness in ordinary lines at least, seem to have passed away.

* * *

TO CUT A THING IN TWO AND YET NOT SEPARATE IT.*

JOHN H. COOPER.

This interesting device has been several times re-invented and patented in modern times. It is a curious mechanical arrangement of well known details, which, like the "nickel-in-the-slot" apparatus, was an old invention in the year 150 B. C., both found in the same book, from which I have made up this condensed history.

From Mr. Bennet Woodcrofts' superior translation of the "Pneumatics of Hero of Alexandria," we learn according to the best evidences presented by manuscripts, still in existence, that this writer (one of the earliest on mechanical subjects) lived in the year 150, B. C.

Although at the commencement of this work, Hero states that he has added his own discoveries to those "handed down by former writers," yet in no instance has he pointed out anything which originated with himself; nor is there any statement in the text, except the one I have just quoted, which would lead the reader to any other conclusion than that the whole is a compilation from the works of those who at that period of time were styled the "*antient philosophers and mechanicians.*"

I reproduce the original heading and give the description of the device, adding a figure of it, also copied from the book referred to:

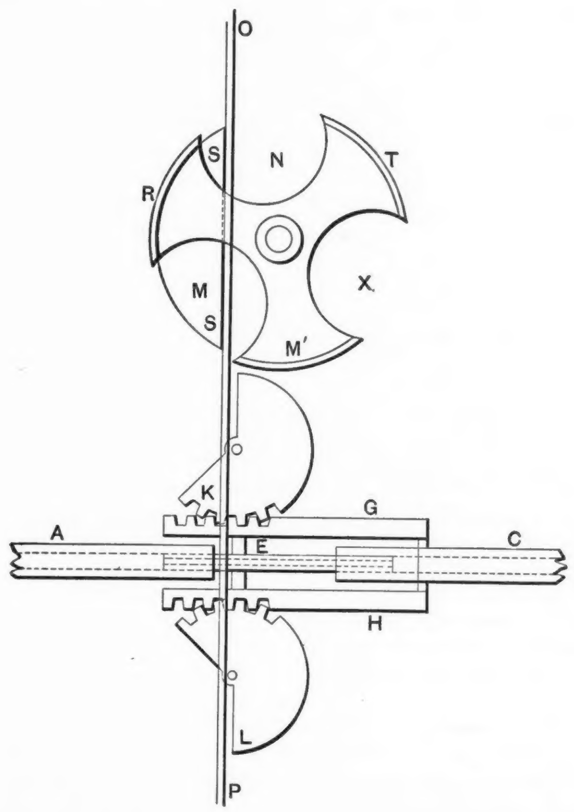
"*An Automaton, the head of which continues attached to the body, after a knife has entered the neck at one side, passed completely through it and out at the other, the animal will drink immediately after the operation.*"

In the neck of the animal next the head let there be a tube A, and in the neck next the body another tube C, passing along through the body, down a leg and through a foot, secretly to a closed vessel or drain. Between these tubes and within them for a short distance, closely fitting, let another tube E pass to which are attached toothed bars G and H. Above G place a toothed segment K turning upon its axis in suitable bearings, and in like manner beneath H a similar toothed wheel L. Over all let there be a trifoliated wheel M^1, on an axis in bearings, the periphery of which is flanged on each side, and let sections be cut out of this wheel by the three circles M, N and X, so that the interval between each division may be equal to the radius of the wheel. O P is an incision or slit across and through the neck of the animal, severing the head completely from the body; the double flanges R of the trifolium should embrace opposite segments S, which are fastened to the head part of the neck, while the three wheels and the tube C are secured in the body side of the neck. Now if a knife is passed down through the incision O P, it will enter the space in N, one of the clefts in the wheel M^1; pressing the knife upon the wheel M^1 it will turn it one-third of a revolution. The cleft N which the knife entered will take the place of the cleft M, and X will take the place of N; the knife will pass out of M and go towards K, and the flanges T will take the place of R, so that the head of the animal will be as secure after the knife has passed the wheel M^1 as it was before. Pressing the knife still further it will come in contact with the sloping edge of the wheel K, moving K towards G to let the knife pass, during

* See page 302.

which action the bars G and H are thrown back, carrying with them the tube E into the tube C, and at the same time withdrawing it from A and throwing L forward across the slit O P, as K was when the knife touched it. By construction, the teeth of the wheels K and L engaging in the teeth of the united bars G and H, there is a simultaneous movement of all these connected parts towards C, making the way clear for the knife to pass by the tube ends and not be arrested till it comes against L, which, if pressed by the knife, as was done at K, it and connected parts will be thrown into the position shown, permitting the knife to pass out of the slit, restoring the pipe connection and of course allowing water to flow through the several pipes the same as if they had not been severed.

When a boy at school I was told by a teacher that there is existing a method of cutting a cane's head off and yet not detaching it. Could I tell how that is done? I could not at the time, but soon found out how to do it. From what source or knowledge I "got on to it," is lost to memory, but I made a cane-head, enclosing in its neck the trefoliated wheel and segments, same as shown in this figure.



In the Novelty Exhibition of the Franklin Institute, in 1865, was a device for permitting the gripping apparatus of a cable railway to hold on to the lower rope at a crossing, and at the same time permitting the upper rope to pass through the "grip" without destroying the integrity of its parts as a gripping device.

These statements serve as connecting links between the long, long ago and the now, proving re-invention to be an oft-repeated performance. This device will also call to mind the words of the poet Milton: "The Invention—so easy it seems when found, which yet unfound most would think impossible."

* * *

Different substances require different amounts of heat to raise their temperature through the same range. As water requires the most heat of any common substance to raise its temperature one degree, it is taken as the base and all other substances measured by it. One pound of wrought iron will be raised one degree with about one-ninth the heat required for the same weight of water, the exact figure being .1138. Cast iron is .1298, steel .1165. brass .0939, copper .0920, and lead .0314. These mean that if it requires 10 000 heat units to raise a certain weight of water a definite number of degrees, it will require but 1 138 of these heat units to raise the same weight of wrought iron the same number of degrees. Then, with these same conditions, it will require 1 298 heat units for cast iron, 1 165 for steel, 939 for brass, 920 for copper, and 314 for lead.

LOSS BY WIRE DRAWING.

W. H. Booth.

For many years after the introduction of the Corliss engine, the principle of expansion was credited with the whole of the gain which was found to accompany the use of automatic variable expansion gear. In engines other than Corliss engines there was a gain from expansion in place of throttling. Is there any explanation which can be adduced other than, or in addition to this one of expansion? So far as the Corliss engine is concerned, it may be definitely laid down that the position of the exhaust valves, beneath and opposite to the inlet valves, ready to receive all moisture and drain the cylinder every stroke, as perfectly as it can be at the exhaust, would in itself account for a very large improvement in economy. Steam wetness has strangely enough been very much neglected, though forty years ago it was found out that superheating, the very opposite of wetness, was a great source of economy. Despite this, however, a wet cylinder was only looked upon as undesirable because the pressure of water was, when excessive, apt to cause breakdowns, and in the days of large and ponderous beam engines, an additional half ounce of water beyond the critical amount would bring into one magnificent scrap heap the beam, connecting rod, and at times even fly-wheel and columns. Before the days of cut-off gear it was very customary to work at a low pressure and carry steam late in the stroke, say to three-fourths, and much of the steam of course did very little work indeed. When cut-off was introduced and pressures raised, it is very easy to understand that there would be an enormous saving between a cut-off at half stroke and one at three-fourths, and the system of throttling was condemned more than it really deserved. Expansion was looked upon as a magnificent idea, and many men unable to see that in all systems and in all processes one cannot reason out extremes from the behavior along a limited line, at once went to excess and only limited their demands by the purse depth of their clients. Expansion beyond sixfold was soon found to be an expensive delusion in a single cylinder. Although other expansion gears did not afford the good water drainage of the Corliss valve, yet the improvements made in engines built to expand, their higher speed of revolution and higher working pressures combined to render all or most moderate expansion engines superior to throttling engines. When, however, we think that the limit of expansion was about six in a single cylinder, it will become apparent to us that in an engine large enough to do its work at boiler pressure with ten expansions, it would be just as well that it should be set to work only at six expansions and the boiler pressure throttled down in the period before cut-off.

In such an engine even the last entering steam will expand sixfold. Personally I was brought up (I am afraid to say how many years ago) on the combined system. The shop where I worked built their engines with automatic expansion gear, and had done so long enough before either Corliss or Sickles stepped upon the stage, but they did not carry expansion to its limits. They throttled as well, and it is not a little amusing to me in what I will term my old age, to find elaborately mathematical papers appearing before engineering societies of various sorts, in which it is sought to prove that that throttling has its virtues within given limits, and the doctrine is thrust fiercely down the throats of engineers to-day as though quite fresh, though it is ancient history even to such as myself.

One case which came under my notice may be cited here to show the direction in which throttling works. A man I knew had an old engine and a good new boiler, and he was obliged to throttle down the boiler pressure because the slow old weak engine, revolving only occasionally, as someone once said, could not withstand the full boiler pressure. After working in this manner for some time, the proprietor suddenly became alive to the fact that though he never had an indicator diagram that showed a bigger initial pressure than 25 pounds, he was carrying 75 pounds on his boiler and was therefore 50 pounds nearer to unnecessary danger and wreck. Alarmed for his new boiler he promptly reduced his working pressure to 30 pounds and got very much the same shaped diagram from his engine, but he now had a nearly open throttle-valve, whereas formerly he had a nearly closed one. Now what was the result? The engine would not drive the load; more coal was used and the proprietor, if he had only known it, had a very useful object lesson in superheating. He had been offered the chance of thinking out why it was that

high pressure steam throttled down, was more effective than straight low pressure steam.

If he rightly read his lesson he would perceive that the high pressure steam began at a higher temperature, and he would learn by inquiry that when steam expands without performing work external to itself, its energy is converted by internal molecular friction into heat, which becomes thermometrically sensible. If the steam is dry to begin with, the expanded steam will be superheated or hotter than it could exist in the presence of water. If wet to begin with, some or all such wetness would be dried out of it. Now wet steam or dry steam has not in itself any particular action for or against economy, but all practice and reasoning tell plainly that a cylinder which can, upon its surfaces in contact with the working steam rapidly approximate to the temperature of such steam, will act most prejudicially against economy.

We all know, or ought to know, if we have read of Hirn's labors and the earlier English superheaters, that every step towards steam dryness or towards superheat is accompanied by an economy limit, greatly in excess of anything that can be explained by the small amount of additional heat, and we can only explain the great benefit by allowing the action of the cylinder metal to be such as Hirn has so well reasoned out.

That so little has been understood of the matter is a little curious in face of the fact that it was the great and prominent fact of cylinder action that led Watt to invent the separate condenser, and to write his famous words about keeping the cylinder as hot as the steam that entered it. All engineers of the time grasped the significance and importance of the separate condenser, but failed to distinguish or rather to appreciate that the cylinder still acted as hitherto, although no water was thrown into it. They did not see that the cylinder was, so to speak, alternately hot and cold, and so the pernicious influence went on. Where formerly the cylinder temperature ranged from say 220° to 100°, or only 110° in very many cases, it soon ranged from about 250° down to 110°. The actual range was even greater than before as pressures rose, and the only reason that the loss was not so great was because the amount of water in the cylinder was so much less than when it was injected for condensation purposes, and could boil off during exhaust and rob the cylinder of enormous amounts of heat.

If now we take the case of the modern engine there will be a point where expansion begins to be superior to throttling. This point depends upon so many factors that it would be difficult to lay it down closely. Above this point expansion loses its benefits, and as superheating is a real benefit, it is obvious that as the benefit from expansion approximates its higher limit, the benefit from throttling begins to rise. Where the two coincide is the critical point, and above that point the benefit arising from the superheat due to throttling is greater than the value of further expansion. It is above this point that the friction of restricted passages ceases to be harmful, for such passages simply serve the purpose of a throttle valve. Further, restricted passages and ports are a positive advantage in such cases, for the very obvious reason that they reduce the exposed area of metal and diminish cylinder condensation. There is no direct loss from reduced passage. If so reduced that a possible expansion of five times were reduced, say to two or three, then there would be waste, for the superheat would be worth less than the expansion at such low ratios. The best practice is to keep the ports as small as is consistent with admitting the highest proper cylinder pressure, to work the boiler always at its maximum pressure and throttle by restricting ports and passages, rather than by a special valve.

This course pre-supposes separate exhaust valves, because the escaping velocity of the wet exhaust steam is low, and ports that may be large enough for initial steam may cause back pressure. Apart from this question of port and passage friction, but allied to it, is the question of valve and piston friction. The work expended in overcoming friction appears as heat, and so far is not actually lost. It reappears as so much superheat, but so far as regards the valve, such heat is probably carried largely away by the exhaust and does no good. Heat generated by the piston warms the cylinder exactly as Count Rumford's cannon boring experiment warmed water. Of course this is not an economical way of adding heat to steam in the cylinder, and does not commend itself as an aid to economy, but so far as it goes, it is there and is not all loss.

To sum up I would say there is no loss from wiredrawing of steam, but that such wiredrawing is probably not to be economically employed in place of expansion, save where expansive working is being carried to excess. In other words, cut-off almost as early as the higher limit of expansion, about five expansions for each cylinder, or five, ten or fifteen expansions for single, compound and triple expansion engines, and carry boiler pressure as much above initial cylinder pressure as possible, and do the rest with the throttle valve. In such a system of working all detent or trip gears, noisy or otherwise, it any, are avoided and the maximum economy may thereby be secured.

As in everything else economical, expansion is a compromise between a large number of conflicting factors. Steam engine practice is made up of many flowing quantities. To strive with one quantity only in view is to court failure. Experimental steam engines have been and will no doubt continue to be great helps to the attainment of correct ideas and methods of working, if properly employed, and the obtained results looked upon as indicators and not as rigid gauge marks for practice.

* * *

LEGISLATIVE INTERFERENCE.

It is said that a bill has been introduced to head off the premium patent attorneys, by making it illegal to offer awards, prizes, etc., for meritorious patents. This is the old story of trying to cure every ill by legislation. While we are opposed to the practice of these attorneys, we consider they have a perfect right to offer as many prizes as they please, just as manufacturers might offer prizes to their employes for the best devices to improve their business. It is simply lack of judgment on the part of the clients, and the attorney is not slow to take advantage of it.

This is very similar to the "gold brick" and "green goods" schemes, which exist solely because there are men anxious to overstep natural law and secure something for nothing. As long as people are attracted by such devices they will continue to be used, and our only object in exposing some of the methods is to make men see that they are used simply to attract the unwary or unthinking mechanic. When people will learn not to patronize the premium houses, they will go out of business; legislation only aggravates the evil.

* * *

INTERMITTENT GEARS.

This is a form of mechanical movement which is extremely interesting and useful, and which can many times be used in place of more complicated devices, for transmitting motion at intermittent periods. From the treatise on this subject by Mr. Frank Burgess we reproduce two forms of these gears. The author says:

"When the driver for intermittents is small and is to run at great speed, and the number of stops in the driven gear is more than five, we advise a style similar to Fig. 1, which is one form of roll or stud intermittent. As compared with the ordinary spur intermittent, the action is much smoother and consequently it takes less power to perform the work. If constructed correctly it will usually give satisfactory results. The driven gear is

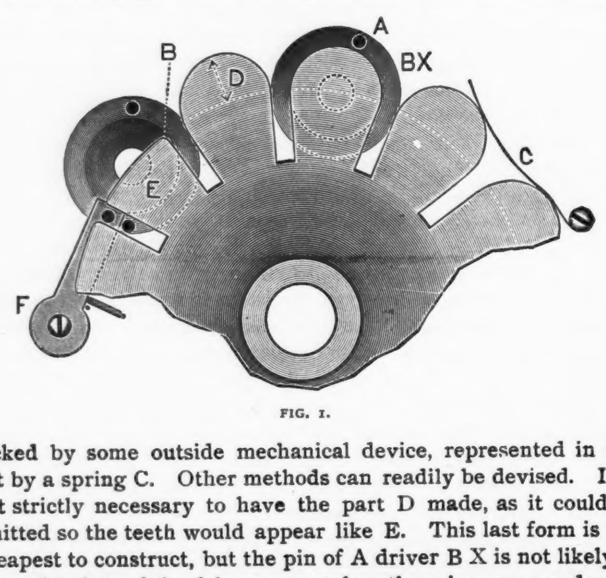


FIG. 1.

locked by some outside mechanical device, represented in the cut by a spring C. Other methods can readily be devised. It is not strictly necessary to have the part D made, as it could be omitted so the teeth would appear like E. This last form is the cheapest to construct, but the pin of A driver B X is not likely to enter the slots of the driven gear unless there is some good positive locking device. Interference, if any, can be avoided by

making the corners of the slots a trifle curved, as illustrated in Fig. 2.

"While the pin on the driver revolves on the outside semi-circle the driven is at rest. While the pin is in one of the slots the motion is transmitted to the driven wheel. In this style of intermittent the driven is at rest during one-half revolution of the driver.

"Fig. 2 represents a set of miter intermittent gears. In this set the driver makes one revolution to one-quarter of a revolution of the driven. This style can be be made in nearly as many combinations as are possible with spur gears, but is usually more difficult to manufacture.

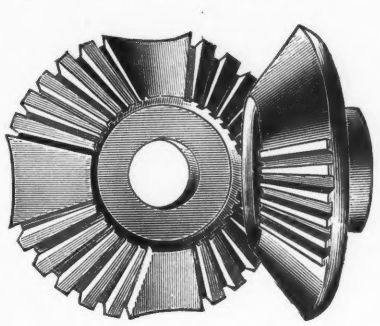


FIG. 2.

"The heel of the driver is formed by milling the blanks to the center angle with the cutter set to that angle in place of the cut angle. See miter gear chart.

"The heel pocket of the driven gear is much more difficult to mill, unless a special milling tool is made of conical shape exactly the same as the pitch cone of the driving gear. If cut with this tool, perfect gears can be obtained."

* * *

NOTES FROM NOTOWN.—18.

Ichabod Podunk.

THE SQUEEZUM CAN CO.—MANAGING FACTORIES—CUTTING PRICES—THE MEANEST MAN.

It has always seemed strange to me how some concerns, with apparently the same shop equipment as their neighbor, could cut under them so much in price, and I was on the point of asking Mr. B. what he thought about it, when he wandered up to my corner with a young chap who manages an oil can business and makes money for his company, too. I'll call the young fellow Mr. Bean, because that wasn't his name, and what he said kind of opened my eyes a little as to some business methods.

Of course he wanted to sell Mr. B. oil cans; he didn't forget business even if it was kind of a pleasure visit, but Mr. B. said: "Sorry I can't buy of you, Mr. Bean, but we have a good supply now—about a half gross we haven't used yet. Bought a lot from the Squeezum Can Co. at a low figure. By the way, how can they sell their best grade for 20 per cent. less than you do, and make money?" "They can't," was the laconic answer. "But they do; at least they sell 'em lower anyhow, and guess they don't lose any money."

"Yes, they do sell 'em lower than we do, but ask the stockholders about the money part. I'll tell you now, Mr. B., we are not doing business for the fun of it. Our stockholders want more than promises, and if they didn't get it—well, I'd be out of a job. I'll tell you about this Squeezum Can Co., and its all facts, too; I happen to know, because an uncle of mine is in it—and wishes he wasn't. They were organized by a good talker, and a little town up in the woods offered them a plot of ground and no taxes for ten years, if they'd build. They built a shop, pirated every reputable oil can on the market and (though some of them wouldn't hold oil when new) sold a good many cans at very low prices. The stockholders were shown figures which were said to represent the cost of production, and the apparent profit seemed to satisfy them.

"As with many other concerns, the cost figures didn't allow for depreciation of machinery, or many of the minor expenses, and though there ought to have been a good surplus at the end of the year, it seemed to have lost itself somewhere. 'But,' explained the manager, 'we're in good shape now, and next year we expect to make a handsome profit.' The same tale had to be told again, old stockholders dropped out and new ones, with more money than knowledge of oil can manufacture, stepped in and things went on as before. Then came the gradually increasing hard times in '91 and '92, the smash in '93 and the hanging on the ragged edge ever since, as you probably know well enough, Mr. B., perhaps too well.

"Well, they had to do something to make a show, so they cut prices, and between you and I and the lamp-post, Mr. B., I'll bet they didn't begin to make additional sales enough to pay the difference in price. It's a poor plan to cut prices when no one wants the goods at any price. Why, many a shop wouldn't have taken a gross of cans as a gift, for fear they might have to pay storage on 'em. We held our prices, and while we didn't sell many cans, we haven't got to fight to get back to legitimate prices, which is almost impossible after you once lower your rates. We haven't made very much money in the last few years, but we have made some—enough to satisfy stockholders; the plant is in good shape to do business when it comes, and we hope to make more in the future.

"The Squeezem Can Co. is looking at another factory site in another town, with another plot of land and no taxes as a chromo. It's a case of getting money put into the concern and giving none back. Makes a job for the promoters, but can hardly be called legitimate business. But there's more than one pirating concern that is doing business in the same way. Not that pirating a device means that you must run the business on the wild-cat plan, but when you find a man who hasn't gumption enough to make something of his own, the other attributes are usually found in the same concern. Sorry I can't sell you any cans to-day, but I'll call again when I'm in town." And he left Mr. B. thinking it all over.

It happens that I've heard a little about the antics of this company, and this explained a few of the things I'd been thinking of. Guess more than one concern is doing a "rushing business" in the same way.

I've read about mean men, men who stopped eight-day clocks at night so they needn't be wound but once in two weeks, to save wear and tear on the key; men who wouldn't let a child dance on a barn floor because it might settle hay in the mow and grain in the bin before they sold it; but young Tom Broom, who runs the old Broom Co.'s shop since his father died, goes 'em all one better. One of his best machinists, Johnson by name, had a big piece of work on the face-plate which Broom was in a hurry for. The old lathe chattered a little, as old lathes will, and sometimes new ones for that matter, and Johnson grabbed up an old monkey wrench to tighten down on the spindle boxes to stop the chattering. Of course it's a little careless to do this when the lathe is running, and you have the big face-plate on, for the wrench can catch and not half try, but we've all done it and probably would again if we were in a hurry; although this ought to be something of a warning in this respect. Well, Johnson didn't get the wrench moved around in time and a rib on the back of the face-plate caught it, twisted the wrench into cork-screw, and, worst of all, jammed Johnson's hand up in bad shape so that he had to have it dressed by a surgeon and lose two or three weeks' time besides. Almost any respectable firm would have helped him out a little, even if they didn't pay him full time, seeing that he was hustling to help them out when he was hurt, but what do you think T. Broom did? Pay him half time or pay the surgeon? That's because you don't know T. B. No, he told the foreman to dock him for the time he lost that day and charge him with the cost of the monkey wrench, which, considering the wrench didn't cost over a dollar when it was new, and was a fit subject for the scrap heap when it was broken, entitles T. B. to the medal, according to my way of thinking.

If you think this is a ghost story, Mr. Editor, just come to Notown and I'll introduce you to Johnson and his foreman, besides showing you Mr. T.B. himself; but I'll be jiggered if I'd ask even an Editor to shake hands with him; so I won't introduce you. P. S. This is no reflection on the Editor; I suppose he shakes hands with all kinds of men, good, bad and indifferent, but none like T. B.

* * *

The *Journal of Trade Journals* has made its appearance from Birmingham, England, and is edited by Mr. Gilbert Little, who must be an adept at using shears and paste, as the whole thing, excepting several editorials, is clippings, as in fact the title indicates. It frankly states that it has come into existence solely for the benefit of advertisers, indeed the reader is not mentioned; probably because there will be few, if any, to such a paper. It has a big contract on hand, for it says: "We shall hide our faces, after a year's work, if we do not procure for every £50 spent in the *Journal of Trade Journals*, orders ten times the volume and value booked hitherto, at an expense of £500 in any other trade publication." We suppose we may as well give up the ghost now as later.

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JUNE, 1897.

CONTENTS:

LOOKING AT BOTH SIDES.

There is practically no improvement which does not have its objections—no change which does not introduce new difficulties as well as advantages, and when the improvement is the product of our own brain, we are too apt to see only the good points and to overlook the weak or objectionable ones. Here is where the friendly offices of the experienced critic are of value; for, being an outside party, he can see both sides better than the man who originated the device, and an honest criticism of weak points is often of much value, while the fulsome praise of a would-be friend is often a positive injury.

When one is continually criticising devices, however, he is apt to become calloused to new ideas and too biased in a measure, because he has seen so many new ideas fail to be improvements. So, if after considering all the objections of the critic, the advantages seem to more than offset them, it would be well to consult another critic.

Among the points to be considered are: Cost of construction as compared with old method; saving to be effected; durability (this includes the introduction of additional parts or joints and the chance of wear affecting the accuracy of the output and likelihood of derangement). If the device stands criticism on these points, and shows more good points than weak ones, it is at least worth a trial.

* * *

THERE is more in grinding tools properly than many imagine, and we believe it is only a question of time and education when lathe and planer tools will be ground in the tool room just as much as drills and reamers are at present. The men will, for the most part, be glad to let some one else grind the tools for them, and the "pet" angles will give way to a standard which suits the work in hand. This will prove more of a money saver than most people imagine.

* * *

A WORD OF WARNING.

There is more than one side to most questions, and the use of shop kinks is no exception to the general rule, so while we believe in "kinks"—believe that much good results from illustrating and describing them—there is a chance of their use being carried to the extreme and becoming uneconomical. In the shop which is managed by a level-headed mechanic there is little danger of this, and in fact there are comparatively few shops which go to extremes in this matter. Still, the danger exists, and when a man gets the kink idea too closely tangled up in his brain, he is apt to lose money rather than make it, by their excessive use.

In jobbing shops, where the work is so varied as to require special devices on many jobs, the kink deviser is a valuable man, especially if the kinks are of the rough and ready order which can be made and used quickly. But when the use of such devices is made to prevent the purchase of regular tools for this work, the kink ceases to be an economical device. This can be illustrated by a case that comes to mind.

A machine shop was started in a small way, and a neat little milling device was made to be used on the lathe, which did good work and handled all they had to do very nicely. The shop grew, as some shops will; the milling work increased rapidly until the little machine had to be used most of the time. Of course it couldn't mill as quickly as a regular milling machine—that couldn't be expected—but it was such a nice little device they didn't like to lay it aside. It milled pretty well, not so very much slower than a regular machine, and then a good milling machine cost several hundred dollars; so they argued they couldn't afford to buy a new miller. They forgot, however, that they were losing the use of the lathe on which the device was used, which, in addition to the inefficiency of the device as compared with a regular milling machine, made quite a little loss instead of a gain—enough to have paid for a milling machine in a few months.

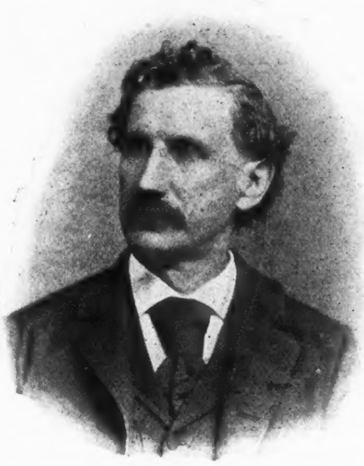
Improvised devices, or tools "rigged up for the occasion," have their place in almost any shop, but they should not be allowed to lose money, instead of saving it, by preventing the purchase of regular tools for the work as soon as the use of the machine will warrant it.

With this warning in mind, it will be perfectly safe to use any of the kinks we have illustrated and to send us any you may have, without feeling guilty of tempting your fellow mechanic to lose money by using your kink instead of purchasing a new machine.

* * *

PRACTICAL PATTERN MAKING.—1.

I. McKim Chase.



The art of pattern-making comprises the modeling of objects that are intended to be cast of metals. Its origin is contemporaneous with that of the casting of bronze, and like that of the latter, the period of its inception is lost in the oblivion of remote ages.

The first patterns were probably made of clay or of similar material, and were models of those rude bronze castings that have been found in ancient ruins. At a later period wax was employed for patterns which represented the more artistic bronze articles. In both these methods the models were usually destroyed in the process of moulding, and their consequent disappearance, in conjunction with the then existent limited knowledge of bronze founding, made the castings rare and valuable.

In the ancient wax process the modeling was done directly in the wax. When the object was large a core representing the interior form of the object was made of the same materials that formed the mould. Over this the wax was modeled and the mould was built around the model or pattern thus formed. In building the mould, inlets or gates through which the metal entered, and vents through which the gases escaped from the mould were provided; these were also represented in wax. When the mould was heated in the process of baking, the wax melted and escaped through outlets provided for the purpose during the construction of the mould.

Wax is still used for patterns, although chiefly for ornamental work. In the modern process the modeling is done in clay, and a plaster mould made of the object thus modeled. The wax model is then produced by filling the plaster mould with molten wax. Plaster patterns are also used to a large extent in ornamental work. The process of producing them is similar to that of making wax patterns.

For many kinds of patterns plaster is a convenient material. It will readily take impressions with fidelity, its durability is such that it will withstand repeated use, and it is sufficiently cohesive to allow of a pattern being made in sections for convenience in moulding.

As the various arts requiring castings advanced and demanded larger and more complicated castings, the art of founding progressed with it. To meet this created demand it became necessary to produce larger and more complicated as well as more durable patterns.

Wood, then, of all materials, has been found to possess the qualities which are requisite in the construction of large and intricate patterns at moderate expense. Of the various kinds of wood suitable for pattern work, clear, dry white pine stands pre-eminent. Its abundance and cheapness, the ease with which it can be worked, combined with its constancy in retaining its form has induced its employment for pattern work to a greater extent than all other materials combined. The kind of pine that grows in the neighbornood of the Great Lakes is the best. It is better without knots or sap, although a small knot or a little sap occasionally is not objectionable, especially for large patterns, provided the wood is thoroughly seasoned and dry, for this latter quality is of the first importance.

The shrinkage of white pine across the grain is well understood. It has been asserted that it will also shrink with the grain lengthwise, and under certain conditions this is possible to a small extent when the wood is of curly or cross-grained nature. A case of apparent shrinkage in length of white pine was related to the writer by a reliable person. In making a pattern he joined together two pieces of white pine and then planed off their ends, thus insuring their being of the same length. Subsequently, after the pattern had been used for moulding and had been stored in the pattern loft for some time, it was noticed that the two pieces were of unequal lengths. From the nature of the construction of the pattern and the position of the two pieces in it, the opinion was formed that the shorter piece had shrunk in length. The resistance that soft, white pine offers to compression is not very great. If a piece of this wood, of cross section, small in comparison to its length, is left standing on end a sufficient space of time, it is possible for it to decrease in length owing to its small power of withstanding compression, and thus create the belief that shrinkage was the cause of the change. For all practical purposes it may be said that soft, straight-grained white pine will not change its length by shrinkage.

When patterns are to be subjected to rough usage, or are to be used for many castings, harder woods, such as baywood, cherry ash, maple, etc., are selected. The first-named of these possesses some of the qualities of white pine, in that it is easily worked and will hold its shape well; but it is the most expensive of the woods used. Of late years red-wood has been largely employed in making patterns, but, although somewhat cheaper, it does not work as freely as white pine. Except for large and plain patterns, where the cost of material amounts to a large proportion of the entire expense of construction, the use of red-wood for pattern work is of doubtful economy.

Metal patterns are also largely employed, but of course the original must have been made of wood or other material, and the metal pattern produced by process of founding.

Green-sand moulding is practiced to a greater extent than other methods, because it is the cheapest for producing castings, especially for small work that is to be much duplicated. In this the moulding is done in a suitable sand, moistened sufficiently to make it adhere together. Patterns for green-sand moulding are models of the object to be cast, and are made in such a manner that they may be readily withdrawn from the sand without mutilating the mould. To enable this to be accomplished the pattern is made in two or more sections, as the case necessitates, and so joined together as to allow the different parts to be withdrawn separately and in a manner depending on the form and position of the part. Core prints are provided where necessary to locate and support the cores. Cores are bodies of prepared sand, baked. Their exterior form corresponds to an interior part of a casting or to undercuts on its exterior that will prevent a model of it being withdrawn from the sand. In such a case the pattern is provided with core prints which abolish the undercuts and leave impressions into which cores are inserted to supply the part or parts of the mould made vacant by the core prints.

Dry-sand moulding is next in importance. In this method the moulding is done in sand mixed with materials that will cause it, after being baked in an oven, to adhere firmly together and withstand greater pressure without distortion than with green sand. Another advantage the dry-sand method possesses is that the mould may be "cheeked," as foundrymen say; that is, it may be devided into a number of parts and those parts lifted away to relieve undercuts and similar places in the patterns. Statuary is moulded in this manner.

Patterns for dry-sand moulding are constructed and finished in a similar manner to those for green sand, except that they can often be made with fewer pieces when the mould is to be "cheeked," and drawbacks employed.

Loam moulding is used for the larger and heavier castings. In this method the moulding is not done in a flask, as in the case of the two previously described methods, but is built up of brickwork, strengthened by rods and plates, where necessary. The moulding material is a mixture of sand and other materials of about the consistency of mortar. It is worked into the mould between the pattern and brickwork. By this method the mould can be made into any number of necessary sections, which can be dissembled, thus relieving the pattern and allowing its withdrawal. When the sections are assembled in a pit and clamped together with sand firmly rammed around the mould the latter is prepared for the metal.

In constructing a pattern to be moulded in loam it is advisable

to use wood sparingly, and where it is used provision should be made for its swelling, which it will do by absorbing moisture from the loam. A strike or sweep used in loam moulding is a flat piece of board with the edge so shaped as to conform to the profile of a part of the desired casting by revolving it on a spindle or moving it along guides, as the case requires. The required part of the mould can be formed without necessitating the pattern being worked out for it. A pattern to be moulded in loam is often but a skeleton of woodwork, some parts of it representing corresponding parts of the intended casting and other parts forming guides for sweeps. For instance, the mould for a plain cylinder may be formed altogether with sweeps by securing them to a spindle and revolving them while building up the mould.

Wooden patterns are usually finished with a coating of shellac dissolved in alcohol. This method is quick, furnishing a smooth surface and provides protection against dampness when the pattern does not remain in the mould very long, as generally is the case with green-sand moulding. But when the pattern remains in the mould for a length of time, especially in a loam mould, which is very wet, shellac does not afford a very good protection against the absorption of moisture by the pattern, and swelling is then the result. Painting the pattern is the alternative in this case, but it is seldom practiced in this country, in consequence of its inconvenience. Thoroughly oiling the pattern previously to its being placed in a loam mould is the usual practice.

All metals in passing from the liquid to the solid state suffer expansion when in the plastic condition. It is this feature in the transition that enables metals to take and retain the impressions of moulds with such fidelity. In cooling from the plastic condition to the solid state metals contract; the amount of this contraction to normal temperature will vary for the various kinds of metals. Patterns have therefore to be made larger than the intended casting by this amount and here occurs the necessity on the part of the pattern-maker for the use of discreet judgment based upon extended experience in order to obtain the best possible results, because different kinds or varying mixtures of iron as well as that of alloys will contract with varying amounts. Moreover the varying proportions of castings when made of the same material will vary in their amount of contraction. Thus an extended and plain casting will contract differently from one of more compact form, though they may be of equal weight and cast at the same time and of the same material It is necessary also to make an allowance for the parts of a casting that are to be finished, taking into consideration the liability of imperfection in the form of the casting.

All woods contain moisture to some extent. Wood kept for several years in a dry place will contain 15 or 20 per cent. of water. Wood that has been thoroughly kiln-dried will, when exposed to the air under ordinary circumstances, absorb 5 per cent. of moisture in the first three days and will continue to absorb until it approximates 15 per cent. of water. Wood, however dry, is subject to change; it will swell or shrink according to the humidity of the atmosphere or the hygrometric conditions under which it is placed. These circumstances must be taken into consideration when a pattern is about to be constructed, and the material so manipulated that its swelling and shrinking will counteract each other in order that the pattern may retain its form and dimensions as nearly as possible.

There is another peculiarity of wood—its tendency to warp in one direction, the cause of which needs to be considered when a structure is to be built up with pieces of wood of various shapes and dimensions.

When a tree is sawn across it is observed apparently to be made up of a number of annular rings. One ring is reckoned for each year in the age of the tree. These rings are composed of numerous minute tubes known as capillary tubes. The sap which gives life and growth to the tree is absorbed by its roots from the soil through which they run. This sap is conveyed through the capillary tubes or veins of the tree by a mysterious force known as capillary attraction. When the capillary tubes are deprived of moisture they contract in diameter and consequently the system which they compose becomes smaller.

Fig. 1 illustrates a section of a tree with the capillary tubes somewhat exaggerated. If such a piece is cut at a season of the year when the tubes contain sap, it will split in the course of drying, as shown by Fig. 2, because the outside tubes dry out first and in shrinking the tenacity of the wood is not sufficient to overcome the resistance to compression offered by the wood within, which has not shrunk so much, and consequently as the shrinkage occurs with great force the outer wood is pulled apart. To prevent this tendency to split, a hole is often bored through the center with the grain; this enables the wood to dry and shrink from the inside as well as from the periphery. Fig. 3 shows the section cut with the grain into three parts, and Fig. 4 shows it cut into six parts; they also show the direction in which the shrinkage and warping occurs. A knowledge of this tendency of wood to shrink and warp in drying is important to possess, and a proper regard for it in joining woodwork will avoid many difficulties.

Fig. 1.

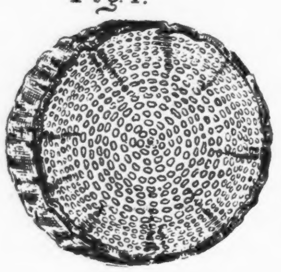
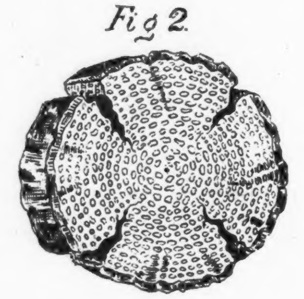


Fig. 2.



Pattern making is of infinite variety and the pattern-maker is never done learning. New forms and devices are continually appearing; these necessitate constant study and scheming on the part of the pattern-maker to meet the new conditions. An extended range of throught, skill and experience is necessary for effiicent pattern-making. A model of an object is not necessarily a pattern, because it may be made in such a manner as to be impracticable to mould it.

To become an expert pattern-maker necessitates talents superior to those required for any of the branches of the machine business except designing. He should possess the qualifications of a moulder and also a draftsman, and must be able to read any mechanical drawing readily and conceive the form and intention of the object illustrated by the draftsman and comprehend its details in the minutest degree. He must be able to determine how and in what manner the object is to be moulded before he can intelligently begin the construction of the pattern, and avoid the errors likely to occur by his inability to do so. Expert pattern-makers are classed with the best general mechanics.

It is a mistaken opinion of some persons that any mechanic working in the trades where the chief material used is wood can work at pattern-making. The pattern-maker is trained to the greatest refinement in the art of working wood.

Fig. 3.

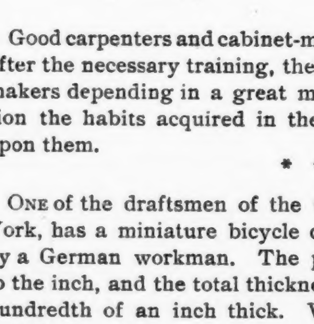
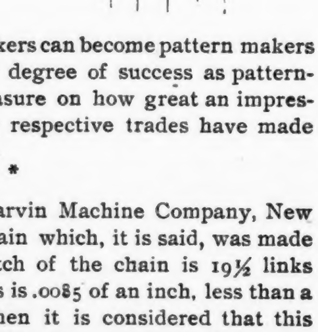


Fig. 4.



Good carpenters and cabinet-makers can become pattern makers after the necessary training, their degree of success as pattern-makers depending in a great measure on how great an impression the habits acquired in their respective trades have made upon them.

* * *

One of the draftsmen of the Garvin Machine Company, New York, has a miniature bicycle chain which, it is said, was made by a German workman. The pitch of the chain is 19½ links to the inch, and the total thickness is .0085 of an inch, less than a hundredth of an inch thick. When it is considered that this includes the block and two side links, the extremely fine work can better be appreciated. Seen under a reading glass, the links are quite regular and well formed.

VALVE GEARS.—8.

E. T. Adams.

THE ANGULARITY OF THE CONNECTING ROD.

After designing the ports and computing the maximum port-opening, by the rule given in the last paper, the steam and exhaust laps may be determined as in Fig. 32 in the April issue. Now, if the crank positions for both forward and return strokes of the piston are drawn as in Fig. 33, it will be seen that the angles turned through by the crank between any two events of the stroke are the same for both strokes. For example, the angle A^1OC, which is the angle turned through by the crank between admission and cut-off for one stroke is exactly equal to the angle B^1OC^1, the angle through which the crank turns on the return

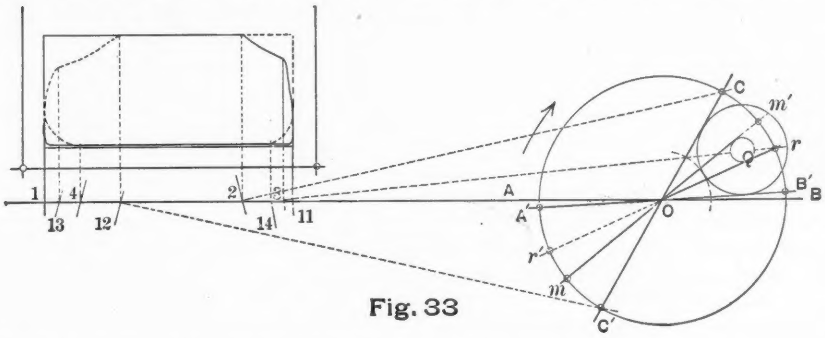


Fig. 33

stroke, and the same relation will be found true for any other events. The lead is also seen to be equal at each end of the cylinder, and in fact a valve designed in this way is said to be *designed for equal lead.*

The positions A^1, C, m^1, etc., are the true positions of the crank pin at admission, cut-off, compression, etc., and the perpendicular dropped from these crank-pin positions to the line A B, locates the "nominal" or *average* position of the piston corresponding to each event. These are not the real piston positions, however, for either stroke; in order to find the true piston positions the length of the connecting-rod must be known and taken into account. In Fig. 33 this length is assumed to be four times the length of the crank; this length is rather short, which will exaggerate the effect of the connecting-rod, and accordingly will, for the present purpose, be better than the more usual length of six times the crank. If we assume, further, that the cylinder is to the left of the shaft as in Fig. 33, and that the engine is "running over," then A^1 is the crank position at admission for the forward stroke and B^1 is the crank position at admission for the return stroke. Now, taking a radius equal to the length of the connecting-rod and the known crank-pin positions as centers, we may strike arcs crossing AB, the center line of the engine, these are really the crosshead positions at the various points in the stroke; but evidently the crosshead and the piston are at the same point in the stroke at the same instant and one will answer our purpose as well as the other.

By aid of the full and dotted lines in Fig. 33, it will appear that 1, 2, 3 and 4 are the piston positions at admission, cut-off, release and compression for the forward stroke, and that 11, 12, 13 and 14 are the corresponding positions for the return stroke. If this is not entirely clear from the figure, take a piece of cardboard or stiff piece of paper and along one edge lay off the distance, 1 A^1, Fig. 33. This will represent the length of the connecting-rod, and using this to measure back from the crank positions in the drawing, it will readily appear how all the piston positions were located. Now, it is evident, without any measurement, that 1, 2 is a longer distance than 11, 12, that is, that during the forward stroke the piston travelled further before cut-off took place than it did up to cut-off on the return stroke, similarly the distance 1,4 will be found to be greater than the distance 11, 14, or there will be greater compression at the head than at the crank end. Broadly speaking, the effect of the angularity of the connecting-rod is to bring all the events of the stroke, except admission, nearer to the crank end of the stroke than they would be otherwise. Cut-off in the forward stroke occurs a little later than $\frac{3}{4}$ of the stroke, and in the return stroke a little before $\frac{3}{4}$ stroke. Similarly, the percentage of the stroke traversed by the piston up to the point where either release or compressions begins, is not the same at the two ends of the stroke, as is clearly shown in Fig. 33, both events being later in the stroke when the piston is at the crank end, and earlier when the piston is at the head end of the cylinder. As a result of all these changes the area of the card at the head end is greater than that from the crank end. Various methods have been proposed and used for equalizing the cards, one of which will be explained in the following paragraph; before leaving this part of the subject, it should be noted that when the valve, as in the present case, is designed *and set* for equal lead, the cards will be as shown in Fig. 33. When the valve is finally adjusted with an indicator, as it should be for best results, it is probable that the eccentric-rod will be changed, making cut-off, release and compression more nearly equal, but making the lead and port-opening somewhat unequal at the two ends of the stroke. This will tend to equalize the cards, making the areas more nearly equal, which is usually more important than having equal lead. Another point to be considered is that slide valve engines are commonly fitted with a throttling governor, and unless the engine is carrying its maximum load the governor will reduce the pressure of the entering steam by "wire-drawing," so that it will be difficult to tell from the card, where cut-off occurs, and of course, under these circumstances equalized cut-off comes to be of less importance.

While it is usual to design a plain slide valve for *equal lead,* it is not uncommon to find that the valve has been designed for *equal cut-off.* Probably the simplest way to do this is to reverse the process used in Fig. 33, and to first locate the piston positions at which cut-off should occur, then to find from these the positions which the crank must occupy. In Fig. 34, 1-11 is laid off to represent the stroke of the piston; this distance is twice the length of the crank and twice the distance 1-11 will be four times the length of the crank or the assumed length of the connecting rod. With this as a radius we may find A and B the two dead-point positions of the crank-pin, through which we draw the crank-pin circle A C B. In this case it is assumed that cut-off will occur when the piston has traversed exactly $\frac{5}{8}$ of each stroke; this locates the cut-off positions of the piston at 2 and 12, and from these by striking arcs cutting the crank-pin circle, as shown; at C and C^1 we locate the true crank-pin positions corresponding to the piston positions which we assumed; C O is the crank-position for cut-off in the forward stroke, and C^1 O is the cut-off position of the crank for the return stroke. Now it is evidently impossible to find one lap-circle which will be tangent to the lead line at l, to the port-opening circle at x and to the two crank positions C O and C^1 O. If we draw a lap circle tangent at l, x and C O, cut-off will occur at 2, which is $\frac{5}{8}$ of the forward stroke. This would locate the crank-pin at D when cut-off occurred on the return stroke, which is nearer to

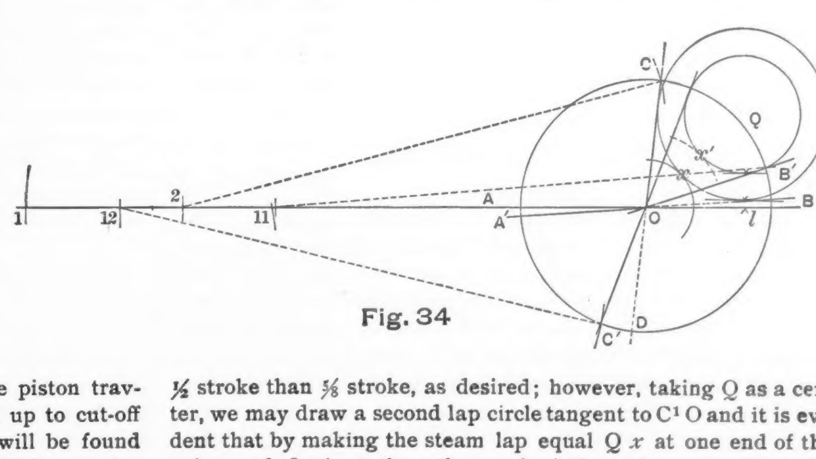


Fig. 34

$\frac{1}{2}$ stroke than $\frac{5}{8}$ stroke, as desired; however, taking Q as a center, we may draw a second lap circle tangent to C^1 O and it is evident that by making the steam lap equal Q x at one end of the valve and Q x^1 at the other end of the valve, cut-off can be exactly equalized as desired. The effect of equalizing cut-off by making the steam laps unequal, is readily seen by reference to Fig. 34. The port-opening at the head end is $o\ x$, equal to the computed value; at the crank end the port-opening has become $o\ x^1$, and as the admission position of the crank for the return stroke has gone back to B^1, we find that the lead has increased from $\frac{1}{8}$ inch, as assumed, to nearly $\frac{1}{4}$ inch, which is far too great.

The process of designing a valve to give equal lead may be summarized by saying that cut-off is equalized by making the lap and lead unequal at the two ends of the valve. The excessive lead at the crank end can be reduced by making the lead at the head end zero or even negative. It is a rather nice question to decide which should be done, and we will not discuss it fully, but the lead, especially if the rotative speed is high, should not be made negative unless the port-opening is ample and the valve travel is sufficient to insure its sharp opening and closing. In the final step in the design the lead will be made zero at the head end.

When cut-off is equalized it is also usual to equalize, as nearly *v* as may be, release and compression. It is not usually possible to equalize both exactly, but both can be made very nearly equal, or, as in the case which follows, compression can be made exactly equal for each end of the stroke, when it will usually be found that release is also practically equal. In Fig. 35 cut-off is made to occur exactly at ⅝ stroke for both forward and return strokes of the piston, and compression begins at each end after the piston has completed $\frac{8}{10}$ of the stroke. These points are drawn as before and from them we find the crank-pin positions A C *m* and B^1 C^1 m^1, for admission cut-off and compression for both forward and return strokes. The steam laps are readily found as in Fig. 34, the lead being zero at the head end. Now the same edge of the valve controls both release and compression at each end of the valve; therefore the small exhaust lap circle drawn tangent to the crank position O *m* for head end compression also determines O *r*, the crank position for head end release. A larger exhaust lap circle drawn tangent to O m^1, the crank end position for crank end compression, also locates O r^1, the crank position for release. It is evident that the distance 11-14 is not exactly equal to the distance 1-13, but release is nearly enough equal for all practical purposes. The

Steam lap head end is Q *h*.
Exhaust " " " " Q *r*.
Steam " crank " " Q *g*.
Exhaust " " " " Q *f*.

The beginner usually has more or less trouble in determining

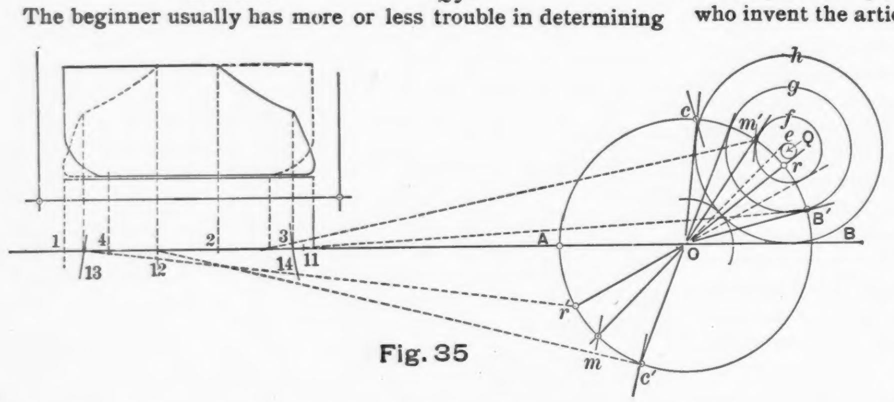


Fig. 35

to which end of the valve any one of the four laps now found should belong. An empirical rule is that the larger steam lap and the smaller exhaust lap belong to the head end. A better plan, however, is to mark each crank position as laid off with some letter which will indicate the end of the valve to which it should belong.

* * *

COMPOUND INDEXING.

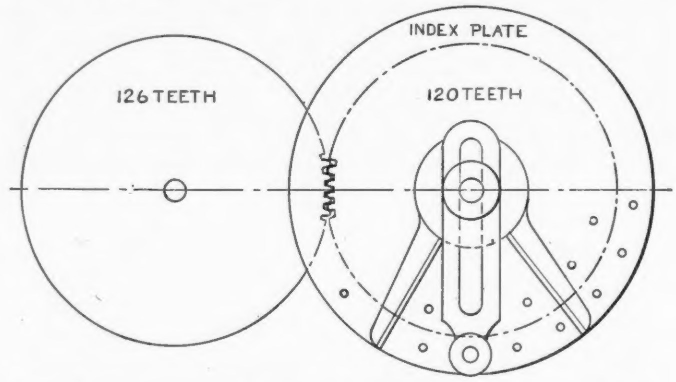
C. E. Price.

I had the same trouble as F. J. Hartwell spoke of in the December issue, but I did not have Walter Gribben's card at hand to look at, and in fact had never heard of it until I read his article. I had done the same as he had, turned the blank first, and when I went to cut the gear which was to contain 63 teeth, I found I could not cut it with the index plate. I tried to figure it out, as I had forgotten the readings of the December issue, but could not get it correctly.

Some time previous to this I thought I would have to cut a dial with 250 spaces, and as the index would not, I figured on doing it by gearing as shown by sketch, but as I did not have to do the job I never tried it. When I failed to figure out the compound indexing I tried the gearing and did as shown in sketch, or partially so, as I did not take the time to fix the index plate on gear, but marked the gear as shown in sketch, and fastened the pin that is used for the index wheel that goes with the Cincinnati milling machine for spacing.

I marked the gear as shown, which contains 120 teeth, and moved ahead 80 teeth, but if I had used the index plate I would use the 66 circle and 44 holes. Where he cuts 81 teeth with an error of $\frac{1}{440}$ and $\frac{2}{440}$, the gearing would cut it correctly.

In cutting 81 teeth you would use the 54 circle, 28 holes and 63 teeth; 42 circle, 28 holes and 57 teeth; 38 circle, 28 holes and 111 teeth; 37 circle, 14 holes.



To cut 250 spaces you have to change the gears to 120 and 96, instead of 126 and 120, and use the 30 circle, 6 holes and 115 teeth; the same gears, 46 circle, 40 holes. The 126 tooth gear is fastened on the worm spindle and a small 6 inch angle iron with an extra spindle made for the 120 tooth gear, and making the spindle so that you can slip the index plate on. A rig like this with different gearing, you can cut any number of spaces and cut them without variations.

* * *

ENGLISH PATENT SCHEMES.

The premium patent idea seems to be spreading. In a recent issue of the *English Mechanic and World of Science*, the Inventors Corporation of London are advertising in the Wedderburn style. They state that "fortunes are awaiting" the ones who invent the articles named in their list of valuable suggestions, for which they charge a shilling, besides requiring a stamped envelope for its return. They say:

"The only feasible way for the average man to attain immediate wealth is to invent something new and useful, and patent it; and the most profitable inventions consist in simple new or improved devices; things of everyday use that everybody wants, and which are in the power of everyone to invent. A good invention is the poor man's only hope of escaping the slave's fetters. One single happy thought, leading to the production of a new thing, has in numberless cases turned the tide of a life. Nothing yields greater profits than patents, and the cost of procuring the patent is now so low as to be within the reach of the poorest."

It is strange how many men are anxiously awaiting the chance of helping the "poor man" to become wealthy. These philanthropists, however, are the ones who wear the best of clothes, have palatial offices and other luxuries, which are supplied by the poor men they profess to assist. When you have an idea worth patenting, don't try the bargain-counter method, for you can save money by getting the advice and services of a good patent attorney.

* * *

SEEN IN VARIOUS SHOPS.—1.

A. Hardcase.

A little more than ten years ago I visited the Brown & Sharpe Mfg. Co., of Providence, R. I., for the first time, when they employed 750 hands, had a floor space of 115 200 square feet, and 155 pages in their catalogue. On a recent visit I was cordially received and shown through the works, which are employing 1 365 hands at present, have a floor space of 278 764 square feet (6½ acres) and 366 pages are required to catalogue their product. I saw many things of interest to me, and will mention a few as seen from the standpoint of a visiting mechanic.

One of the men was setting the cutter on one of their latest gear cutting machines, which seemed to be a model of its kind. He had a little fixture carrying an indicator needle that he clamped

to the V guide by the turn of a thumb screw, making it a quick and easy matter to locate the cutter very accurately and central with the work arbor, as the needle multiplied any error in the position of the cutter. How often I have wished for just such a rig on some of the machines I have used. Near by was a milling machine at work roughing out milling machine vises, removing about $\frac{1}{16}$ of an inch of stock from both edges and the top of the rough casting (which was about 6 inches wide), at one cut, with a feed of 4 inches per minute, or about $\frac{1}{8}$ of an inch per revolution of cutters, the largest of which were two side mills, necessarily about 9 inches in diameter. The only reason I had for noticing this machine in particular was because it was on a long cut where I could see just what it was actually doing, instead of consulting their "adv." to see what it was capable of.

The works are well supplied with good modern tools, and I am afraid that some of those who have never worked anywhere else would feel like fishermen without any tackle if put to work in some of the shops known to the writer.

The library contains about 4 600 volumes, and is open during the noon hour and after 6 o'clock one day each week, and any employee can examine and select such a book as he desires. It is for the free use of the men, and contains a large number of excellent works on fiction and various other subjects besides science and mechanics. The company has also provided a neat little hall where the apprentices' association meets one hour each week in the company's time, for debates, lectures, etc.

Evidently narrow high speed belting is preferred here to the wide slow moving ones, bearing out Brother Cheney's belt argument, as it is used in nearly all cases where possible.

Milling cutters seem to be kept down to the smallest diameter consistent with the work, and *kept sharp* also; and when I say kept sharp I don't mean that the cutters are left until wanted and then the cutting edge "dubbed off" on an emery wheel until they are all out of shape. I saw about $20.00 worth of formed gear cutters spoiled by that method in one small shop, and they were all marked "KEEP SHARP," too.

To those who are running shops that are as far behind in modern practice as the Chinese are behind in up-to-date methods, it may seem strange that Brown & Sharpe would admit a visitor to their works under any circumstances. But their popularity and success during the past ten years as compared with most of those run on the Chinese plan of seclusion, sort of bears out the following explanation:

"Our chief object in showing our works is to have them well known, and we believe our visitors will think of us when needing anything in our line, and will be apt to mention us to their friends. Beyond this we enjoy seeing our friends and acquaintances, and we profit by the exchange of ideas upon mechanical topics."

* * *

MECHANISM FOR MECHANICS.—4.

PROF. CHAS. H. BENJAMIN.

PIECES IN DIRECT CONTACT.

So far, we have considered turning pieces connected by some form of link or rod. In the case of gears and cams the driver and the follower are in direct contact without the intervention of any connecting rod.

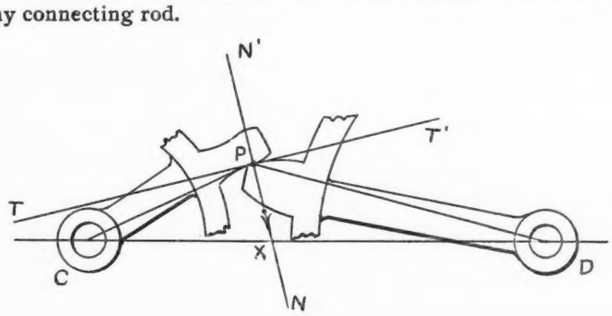


FIG. 12.

It is generally assumed by mechanics that the velocities of gears depend entirely on the numbers of teeth and the diameters of the two wheels. This is true only when the teeth are of just the right shape. To make this plain it will be better to take two teeth which are in contact and consider them alone.

In Fig. 12 are shown two arms of gears carrying one tooth each, and the two teeth in contact at P. Let the arm C P be the driver and the arm D P the follower. Then the upper tooth will be pushing the lower as shown by the arrows, and the action will be the same as that of any two gear teeth when in action. Now we wish to find how fast D P is turning when compared with C P.

Draw the line $T\,T^1$ just touching the two curves at P and draw $N\,N^1$ perpendicular to $T\,T^1$. Then all sliding between the two teeth takes place at this instant along $T\,T^1$, while all the pressure acts in the line $N\,N^1$.

As $N\,N^1$ is the line of pressure, we may consider it an imaginary link or connecting rod; although its length between the teeth is infinitely small, we know its direction just as well as that of a real link.

Now it has been proved in the case of a connecting rod, as in Fig. 7, that *the angular velocities of the two cranks connected by a link are inversely as the segments into which the line of centers is divided by the line of the link.*

We can apply the same principle to our imaginary link, which cuts the line of centers at X, so that C X is two-thirds of D X, and

$$\frac{\text{angular velocity of D P}}{\text{angular velocity of C P}} = \frac{\text{C X}}{\text{D X}} = \frac{2}{3}$$

or D P is turning two-thirds as fast as C P.

We have then this rule for gear teeth: *The angular velocities of two gear wheels are inversely as the segments into which the line of centers is cut, by a line perpendicular to the surfaces of two teeth at their point of contact.*

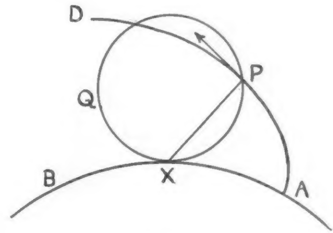


FIG. 13.

CONSTANT VELOCITY IN GEARS.

In order that the velocity ratio may always be the same and the gears run smoothly without jar, the intersection X must always come at the same point on the line of centers. This is accomplished by having the tooth curves of a certain shape, so that whatever the position of the teeth the point X is always the same for the same pair of gears. The curves most commonly used for this purpose are the cycloid and the involute. Before showing why these curves will satisfy the above conditions, it will be necessary to explain the nature of the curves.

A cycloid is in general the curve generated by a point in the circumference of a circle when it is rolling on a straight line or another circle. When the circle rolls outside another circle the curve traced is called an epicycloid; when it rolls inside another circle the term hypocycloid is used, but when the circle rolls on a straight line the curve is simply called a cycloid.

Thus in Fig. 13 the circle P Q is rolling on the circle A B and the point P traces the curve A P D, which is called an epicycloid. In the position shown, the rolling circle has an instantaneous center at X, *i. e.*, at this instant its motion is the same as if it were turning about X as a center.

Draw X P; then will the motion of P at this instant be in a direction perpendicular to X P as shown by the arrow. Consequently X P is perpendicular to the cycloid at the point P. This will of course be true for any position of P. We may say that *the perpendicular to a cycloid at any point passes through the point where the rolling circle touches the stationary circle at that instant.*

The rolling circle is usually called a *describing circle* and the stationary circle a *pitch circle*. The pitch cylinder of a gear is a cylinder having for its radius the radius of the pitch circle, and is of course imaginary. The radii of the pitch cylinders of two gears which are in action have the same ratio as the numbers of teeth in the two gears, and if the two pitch cylinders rolled together without slipping, they would have the same relative velocities as the two gears. The describing circle, then, rolls on the pitch circle, and a point in the describing circle describes the outlines of the teeth.

In Fig. 14 let C and D be the centers of two gears, and suppose it is desired that the gear D shall turn only one-half as fast as the gear C. Then divide the line of centers C D into two parts so that C X shall be one-half of D X and describe the pitch circles A F and B G just touching at X. We will call these the circles C and D.

Let E be the centre of a describing circle less than one-half of the circle D. Measure off on these circles the equal arcs X A,

X B and X P. Now if we will roll the circle E in the direction of the arrow on the circle C, the point P will trace part of an epicycloid P A, and if we roll the same circle in the circle D, the point P will describe part of a hypocycloid P B. These two curves will evidently touch each other at P, and from what has gone before we know that the line P X will be perpendicular to both curves and pass through the point X where circle E touches the circles C and D. But we may take any other point as P^1 and prove the same fact. Therefore if we use the epicycloid A P for a tooth of the gear C and the hypocycloid B P for a tooth of the gear D, then as long as they remain in contact they will touch somewhere on the circle X P, and their common perpendicular will always pass through X. Consequently the angular velocity ratio of the gear D to gear C will be constant and equal to

$$\frac{CX}{DX} = \frac{1}{2}$$

in this case.

Gear teeth which are not of correct shape cause a variation of speed and considerable vibration and noise at high speed.

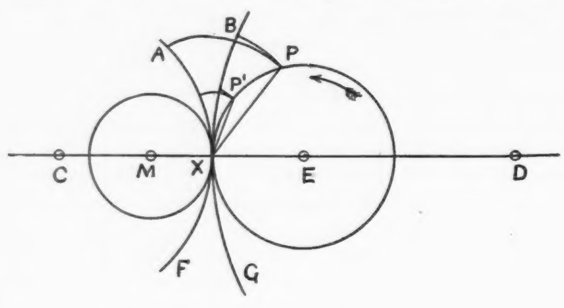


FIG. 14.

The part A P of a gear tooth is called a face, and any part, as B P, which lies inside a pitch circle is called a flank. It will be noticed that the circle E can only be used to trace flanks on the follower D and faces on the driver C. Another circle, as M may be used to trace faces on the gear D and flanks on the gear C, since it will roll outside the former circle and inside the latter

In Fig. 15 are shown the pitch circles of two gears *q q* and Q Q having centers at C and D respectively. The radius C X in this case is two-thirds of D X, and therefore the gear D will turn twice while C turns three times.

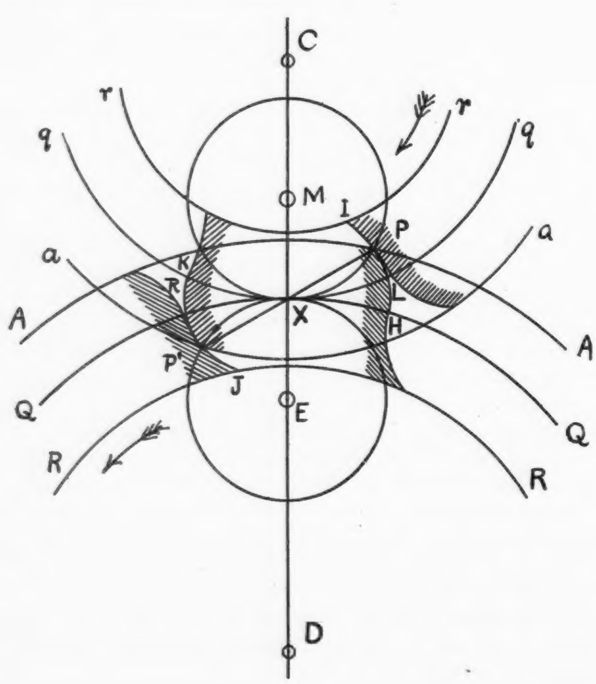


FIG. 15.

Let us assume two equal describing circles with centers M and E. By rolling the circle M on Q Q we trace a face P H for the follower, and by rolling it on *q q* we trace a flank P L for the driver. In a similar manner with the circle E, we can trace a flank P^1 R for the follower and a face P^1 K for the driver.

As the driver C turns in the direction of the arrow, the flank P L will drive the face P H from H to X, the teeth always being in contact along the describing circle P X. This action is called *approach*, and the equal arcs H X and L X are called *arcs of approach*. After leaving X the face of the driver's tooth will push the flank of the follower's tooth from X to R. This action is called *recess*, and the equal arcs X R and X K are called *arcs of recess*.

Notice that during approach, the flank of driver pushes face of follower, while during recess the face of driver pushes flank of follower. The point P is the beginning and the point P^1 the end of contact. During the whole interval the point of contact will be somewhere on the curve P X P^1, and at any instant the common perpendicular to two teeth at the point of contact will pass through X so that the velocity ratio of gear D to gear C will be constant and equal to

$$\frac{CX}{DX} = \frac{2}{3}$$

as desired.

* * *

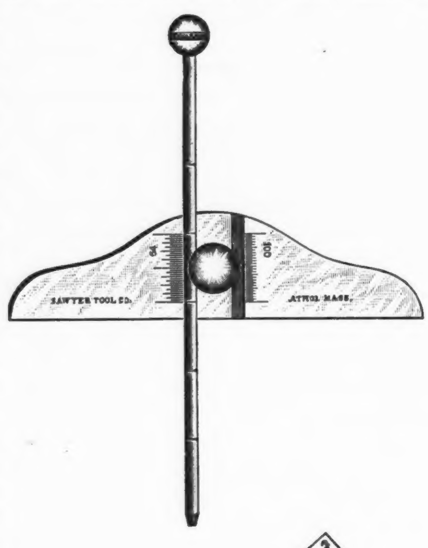
A New York *Herald* reporter recently displayed his engineering brilliancy by stating that the electric motors being tried on the New England R. R. were so successful that it would be possible to produce a horse power with two *tons* of coal, while it now required seven to eight *tons* in the steam locomotive. The italics are ours.

Dividing his figures by 2 000 will give nearer the actual condition.

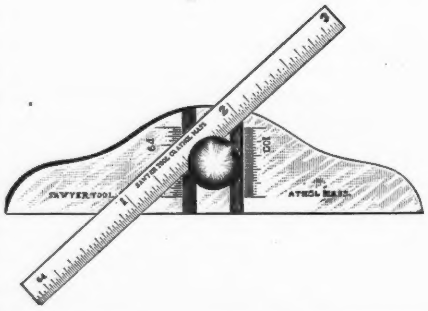
* * *

A NEW DEPTH GAUGE.

This tool was designed to overcome many of the objections to the depth gauges now in use. It is a well known fact that the majority of the work for which such a tool is used, is in gauging the depth of drilled holes and small cavities; for that reason a round bar with a small point is preferable, as the exact depth caused by the point of the drill can be found, or by moving it to the side of the hole you can get the shoulder depth; with a square or oblong gauge bar this cannot be done so closely, but the fact that the bars are usually graduated brings them into favor on that account.



The improvement in this tool lies in the fact that the round bar is divided into half inches, by graduations that extend completely around it. The outer edges of the grooves are graduated in the finer divisions of an inch to correspond to the divisions on the gauge bar, so that when the point of the gauge bar is flush with the straight or working edge the first graduation on the bar matches the first graduation on the stock, so that in any depth gauged the semi-divisions of an inch can be counted, and the fractional part, if any, can be added and the complete depth told quickly without recourse to other means of measuring. Each slot has different divisions of an inch at its outer edge, and the bar can be instantly changed from one to the other as desired. They are graduated in 64th, 100th and 64th and 50th. The round gauge bar can be replaced by a narrow rule which makes a very handy universal bevel for transferring angles and to be used in getting the draft of patterns, etc.; altogether it makes a very desirable tool and and one which all mechanics will thoroughly appreciate. It is made by the Sawyer Tool Co., Athol, Mass.



AUTOMATIC SPROCKET WHEEL CUTTER.

Something of the magnitude of the bicycle industry is suggested in the designing of the special machine for milling sprockets, which we illustrate, and in the further fact that these machines are made and operated in groups of two, four or eight upon a single base. The accompanying engraving (Fig. 1) shows eight machines. The sprockets to be milled are first bored

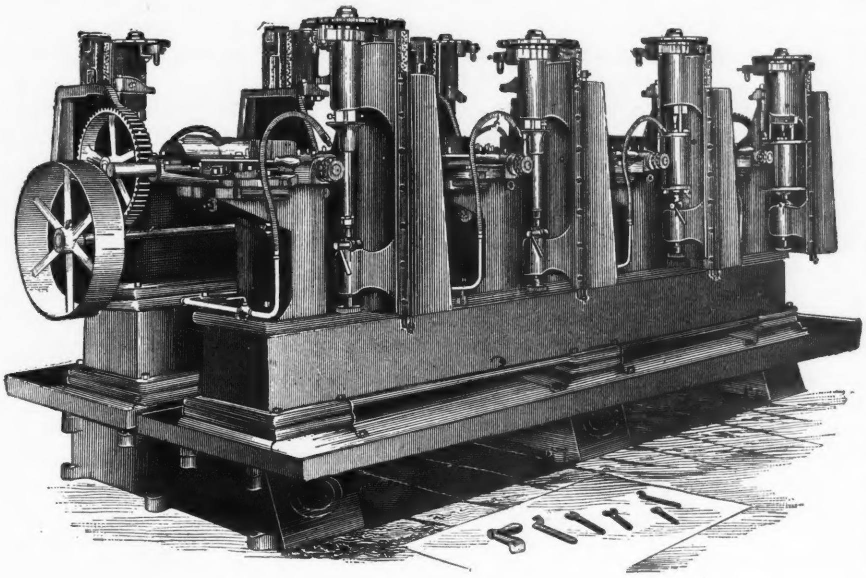


FIG. 1.

and faced, and then clamped together in gangs up to 8 inches long. The machine cuts pinions of eight teeth and sprocket wheels up to 12 inches in diameter. The slides carrying the sprockets feed up by cam and drop by a quick motion, so that little time is lost. The cutter spindle slides are adjustable in and out by a screw, and have a graduated scale to assist in setting the cutters to the proper depth. Each head or machine is independent, being driven by its own clutch, so that when the cutter is stopped the feed and all stop with it. A constant stream of oil is directed on the cutters and the chips fall directly into the pan below, where the oil is drained to the reservoir and is pumped over the work again.

The indexing is entirely automatic, and will be understood from Fig. 2. A ratchet of the same number of divisions as the dial is fast thereon, and this ratchet is moved by a pawl carried on a segment gear meshing in a rack. The rack is moved by a swinging arm on a vertical rock shaft, which motion of the rack is by spring, and changes in indexing are made by regulating the point to which the rack returns, so that more or less of the movement of the swing arm takes place before it meets the rack, the movement of the swing arm being constant. To lock the dial, a lock bolt fitted into notches in the edge of the dial is used, and this bolt is moved by a lever lying in a slot in the back of the slide. This lever on the upward movement of the slide rides over the projection and forces in the lock bolt, and thence holds it under spring tension. On the downward stroke of the slide this lever passes off the projection mentioned, the tension of the lock bolt is released and it is thrown back by a spring. The machine is made by the Garvin Machine Company, New York.

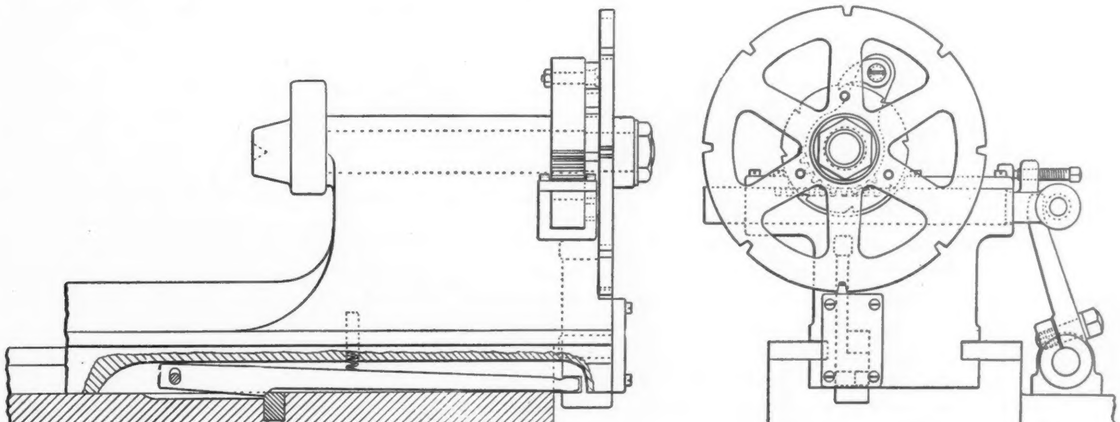


FIG. 2.

* * *

You can get the best results by becoming familiar with the tools you use—knowing their weak and strong points, and also what speed to use.

HOW TO CALCULATE, DESIGN AND CONSTRUCT ELECTRICAL MACHINERY.—1.

Wm. Baxter, Jr.

In this series of articles it is proposed to explain, in a simple manner, the principles upon which electrical machinery acts, and also to give such rules as may be necessary to enable any one of ordinary intelligence to calculate the various parts of such machines. These rules will be given entirely devoid of any mathematical complications, so that any one who understands the four elementary rules of arithmetic will be able to understand and make use of them. In addition to this, the general principles of construction will be given, showing how each part is made, and giving the reason why it is so made.

Those who are not familiar with electricity, look upon the subject as one shrouded in mystery, which can only be thoroughly understood by those who are well versed in science, and who have had the advantage of a mathematical training. This is an entirely incorrect impression, and should be dismissed from the mind at once, as it is difficult to master a subject if we start with the idea that it is beyond our reach. The awe inspiring feature of electricity is due to the fact that it acts through entirely invisible means; but this is also the case with other forces of nature, although we do not notice it because the actions are so common that we forget the force itself, and only see the effect. If we throw a stone from the roof, we forget that it drops to the ground because it is attracted by the force of gravity, and say that it falls by its own weight, but if it were not for the attractive force of gravity, it would have no weight; it is drawn to the ground by an invisible force. We say that the action of a steam engine is easily understood, because we can see the steam that drives it; but the steam does not drive it, it is the heat in the steam, and heat is an invisible force.

We are perplexed when we consider that a small wire can carry to a distance of several miles an electric current that will set in motion a motor capable of developing several horse power, and that while all this power is passing through the wire there is no change in its appearance. If there were any noticeable change we would not be so surprised, as then there would be something to account for the action. Heat acts just as mysteriously, but in a way that does not attract our attention, because we are so familiar with it. A piece of polished metal can be heated to a temperature far above that of boiling water, and no change in its appearance can be detected; but if it is put into a pail of water it will heat the latter, and this in turn will not be changed in appearance, if it does not rise above the boiling point. Thus we see that heat, which acts in so many different ways, is an invisible force, and that it fails to mystify us to the same extent as does electricity, simply because we are more familiar with it.

We do not know what electricity is, and from this fact it is assumed, by those not familiar with the subject, that we cannot handle it with any degree of certainty, that we are groping in the dark, and only obtain results by a cutting and trying process.

This conclusion is very far from being correct, and a little reflection will show that it is not necessary to know what a force is to be able to make use of it in an accurate manner, for if we know *what it will do and under what conditions it will do it*, we are as well off for all practical purposes as if we knew what it is.

So far as actual knowledge is concerned, we are as well off with respect to electricity as we are with respect to heat, gravity, light or chemical action. We know nothing as to the nature of these forces, and as with electricity, our knowledge is limited to a correct understanding of what they do under various conditions.

The student of electricity should therefore understand from the start that he will not find out what the force is, but simply what it can do, and that this knowledge is all that is necessary to enable him to apply it to any practical purpose. To obtain a correct understanding of the subject, it is necessary to begin with the elementary principles, just as it is necessary to master the alphabet before learning how to read, we will therefore commence at the bottom of the ladder and endeavor thereafter to show how these elementary principles explain actions that are apparently complicated in the highest degree.

an electric current is flowing. Such lines are represented in Fig. 3, in which the black circle A represents an end view of a wire in which the current is flowing away from the observer, and the arrows the position that would be taken by a magnet needle at the various points These lines can be obtained experimentally, by holding the wire in a vertical position so that it may pass through a hole in a piece of paper held in a horizontal position. If filings are sprinkled on the paper and the latter is jarred, the filings will arrange themselves in circles, as shown in Fig. 3; and a needle held in any position will always place itself in a line tangent with the circle.

From this last experiment we find that an electric current is encased in a magnetic envelope, and that the direction in which the magnetic force acts is at a right angle to the direction of the electric current, and that a magnetic needle, if placed on top of the wire carrying the current, will point its head to the right when the current is running away from the spectator, at shown in Fig. 4.

A space in which a magnetic force is acting is called a magnetic field, and therefore a wire carrying an electric current is said to be surrounded by a magnetic field. On account of this

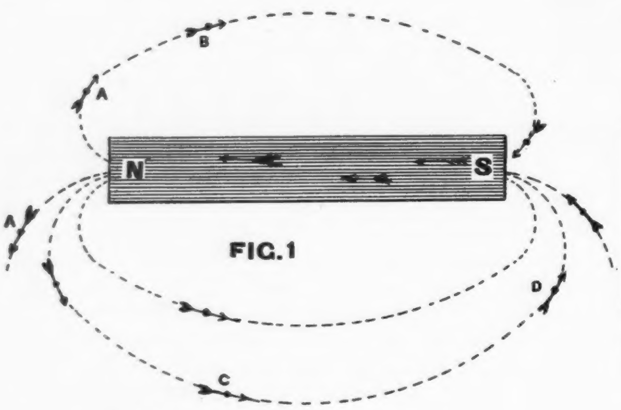


FIG. 1

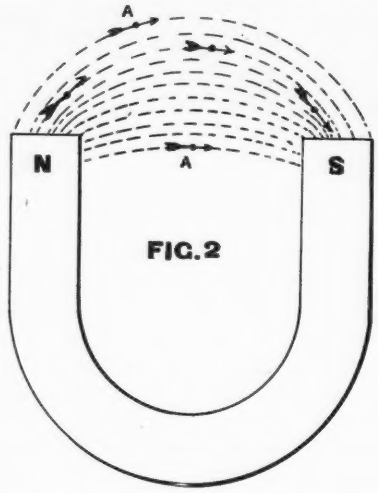


FIG. 2

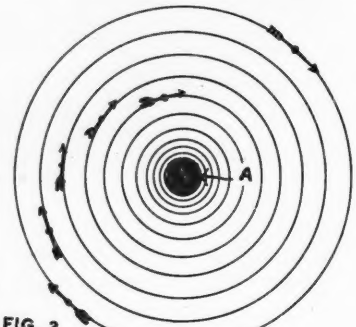


FIG. 3

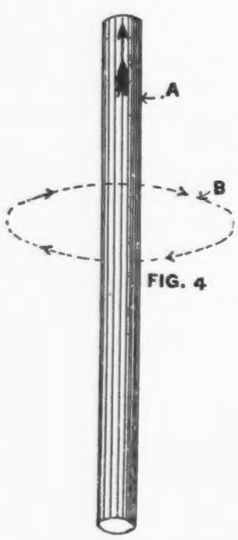


FIG. 4

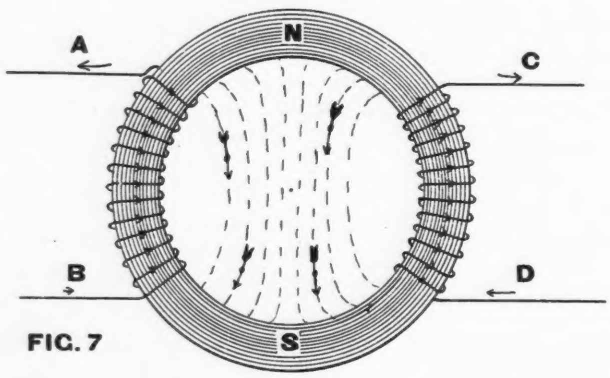


FIG. 7

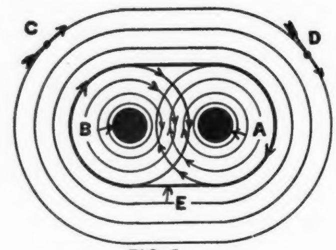


FIG. 5

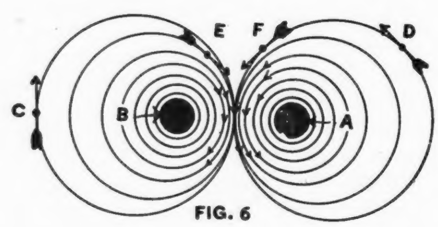


FIG. 6

If you take a steel magnet, as shown in Fig. 1, and hold a small compass near it, the needle will point in a direction dependent upon the position. At any of the points marked A the position will be as indicated by the arrow. If the compass is moved along the upper curve, the position of the needle at any point will be in a line parallel with the curve, as indicated at B. If it is moved along any other path the needle will always place itself in a line parallel with the curve corresponding to that path, as shown by the arrows C D.

If the straight magnet is replaced by one bent into the shape of a U, as shown in Fig. 2, the same results will be obtained, but the shape of the curves will be changed. The best way to get the true shape of these curves is to place a sheet of glass over a magnet and sprinkle some cast iron filings upon it. If the glass is then jarred slightly for a few seconds, it will be noticed that the filings begin to arrange themselves in lines somewhat similar to those shown in the figure. These lines show the direction in which the force of the magnet acts at the various points in its vicinity, and are therefore called the magnetic lines of force. Similar lines can be obtained in the vicinity of a wire in which

intimate relation between electricity and magnetism, it was formerly believed by many that the two were one and the same force acting under different conditions, but certain differences in action conflicted with this assumption. Thus if two magnets are placed side by side, they will repel each other, if the north ends are together, and will attract each other if the north end of one is by the side of the south end of the other; but with two electric currents the result is just the reverse. If the two currents run in the same direction they will attract each other, and if they run in opposite directions they will repel each other. The reason for this difference can be easily explained, and should be remembered, as it plays an important part in all electric actions.

Magnetism is generally supposed to be an attractive force, but it is only so for objects through which it can pass freely. From this it will be understood that magnetism cannot act without encountering resistance; if such were not the case a small magnet energized by a weak magnetising force would be as strong as a large one. If a coil of insulated wire is wound around a bar of iron and a current of electricity is passed through the wire, the

bar will become magnetized, but its strength will be in proportion to the current circulating around it. To make it stronger it is necessary to increase the current. The explanation of this is that the air surrounding the magnet offers a resistance to the passage of the lines of magnetic force. Iron and steel offer less resistance than air, therefore if there is any such metal near a magnet, the lines of force will pass through it, or at least a large portion of them will. As the air resists the passage of the magnetism the lines of force tend to contract, so as to shorten the distance through which they have to travel, and thus reduce the distance to be overcome. If two magnets are placed side by side with their poles in the reverse order, they will attract each other because the lines running through one will be in the same direction as the return lines of the other. This can be seen from Fig. 1, in which it will be noticed that the lines inside and outside of the magnet run in opposite directions, hence the magnetism of each magnet which, if alone, would be compelled to pass through the air, can find a much easier return path through the core of the other magnet. This therefore explains why two magnets with their poles set in opposite directions attract each other.

If the poles of the magnets are in the same direction, the lines of force in the two cores will run in the same direction, and therefore one cannot act as the return path for the other. Under these conditions, if the two are brought close to each other, they will be repelled because the space between them will be contracted, and the lines running through this space will be condensed into a more compact relation to each other.

With two electric currents the attraction is between those running in the same direction and the repulsion between those running in opposite directions. Why this is the case can be seen at once, from Figs. 5 and 6. In Fig. 5 the two wires are represented by the circles A B, and are supposed to be seen end on. In both, the current is running in the same direction, which is down through the paper. As the current runs in the same direction in both wires, the magnetic lines of force around both must be in the same direction, as is indicated by the arrow heads. When these lines meet in the space between the wires, they will come together head on, and will oppose each other's passage, the result being that instead of running in opposition to each other through the center space, they will join hands, so to speak, and encircle both wires and draw these together, through their efforts to reduce the length of the path in which they travel, and thus reduce the resistance they have to overcome.

If the current in the two wires is in opposite directions, the line of force from both wires will meet in the central space running in the same direction, and will therefore not clash. They will not attempt to pass around the opposite wire as in Fig. 5, because they would then meet lines running in the opposite direction which would stop them. This can be seen from the direction in which the compass needles in both figures point. The two wires with the oppositely directed currents will repel each other because the contracted space between them will crowd the lines out of their natural position, which is in circles central with the wire. This crowding effect is shown clearly in Fig. 6.

Many electricians fail to fully realize the fact that lines of force will not pass in opposite directions through the same space, but that this is always true can be shown by the action of a ring magnet, such as is shown in Fig. 7. This figure represents an iron ring wound with two coils of wire, over which two independent currents may be sent. If the current flows in both in the direction indicated by the arrows, the lines of magnetic force developed by each will be oppositely directed, and as a result there will be two poles in the ring, a north pole at the top and a south pole at the bottom. The explanation of this is that the lines of force will sooner pass across the air space from one side to the other of the ring, than to run by each other in opposite directions in the ring itself, notwithstanding that the resistance of the air path is many hundred times as great as that through the iron. That this result actually takes place is well known, and all the multipolar machines have field magnets that depend upon this fact. As will be seen from the arrow heads, the current from wire A B passes from the outside to the inside of the ring, and that from wires C D passes from the center to the outside. If the current in either wire is reversed, the poles at N S will disappear, but the ring will still be a magnet, and capable of acting as such under the proper conditions. Not only will it be a magnet, but it will be more powerful than it was previously, and if it is sawed through at any point the two ends so formed will at once become poles and exhibit an attractive force just as any other magnet.

The space around a magnet, or an electric current that is traversed by the lines of force, is not confined by a positively defined boundary; in fact, theoretically speaking, the magnetic field is unlimited, and extends to the utmost points in space. But in reality the distance at which the action of the magnet can be detected is not very great, except when very sensitive instruments are used, hence the magnetic field of any magnetic or electric current is the space immediately surrounding it.

The theory of lines of force was gotten up for the purpose of presenting to the eye a picture that would convey a proper notion of the manner in which the force of magnetism acts, they have no actual existence, and this fact should be kept in mind; but when the manner in which they are intended to represent actions in a magnetic field is correctly understood, their use serves to render simple, actions that would otherwise prove very puzzling. The main points to remember are: that the lines always run in the same direction through all magnets and around all electric currents, and that when lines from two or more separate sources come together, they will follow the same path thereafter, if running in the same direction, but if not they will follow another path in which all can go in the same direction without disturbing their course before meeting. Lines of force should be regarded as having a tendency to contract and therefore to resist elongation, like elastic strings for example, and by so regarding them we can see how a magnet attracts a piece of iron or why it resists the moving of that piece to a greater distance.

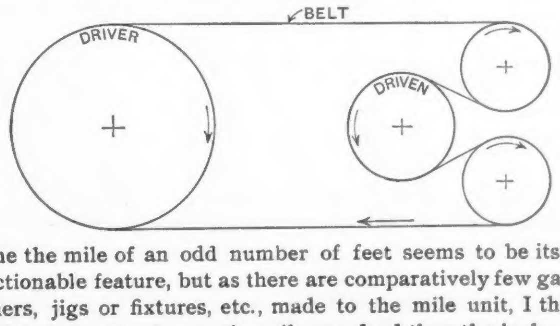
Magnets are divided into two kinds, permanent and electro-magnets; the first are made of steel and are hardened, the second are made of iron or mild steel of the softest kind. Permanent magnets when once magnetized remain so for a long time, but their strength gradually reduces, and in a sufficiently long time would probably disappear entirely. Electro-magnets lose their magnetism as soon as the electric current that magnetizes them is stopped. Magnets of the latter type are by far the strongest, and on account of their strength being dependent upon the current that magnetizes them are of much wider application in practice.

The manner in which an electric current converts a bar of soft iron into a magnet can be understood at once from a consideration of the fact that an electric current is enveloped in a magnetic field, as was explained in connection with Figs. 3, 4 and 5. As was shown in that connection, one wire is surrounded by a circular field, and two wires in which the current runs in the same direction are surrounded by a somewhat elongated field. If the two wires are replaced by a coil and an iron core is inserted within this, it will be traversed by the lines of force constituting the field around the wire coil, and will therefore become a magnet, and will remain such as long as the current flows. In this way an electric current flowing around a bar of iron converts it into a magnet; in what follows it will be shown that moving a magnet in the neighborhood of a wire, or the wire in the neighborhood of a magnet, will cause a current of electricity to flow in the wire.

* * *

METRIC vs. DECIMAL SYSTEM—BELT DRIVE.

Although the editorial published in the February number on "Metric vs. Decimal Systems" does not suggest a *perfect* decimal system of measurements, I think it comes the nearest to a practical solution of the existing conditions that I have seen.



To me the mile of an odd number of feet seems to be its most objectionable feature, but as there are comparatively few gauges, reamers, jigs or fixtures, etc., made to the mile unit, I think it would be better to change the mile standard than the inch.

As one of the compromises in engineering, I will mention the following problem which was solved by Mr. Fay, of Fay & Scott, Dexter, Me., for the Piscataquis Woolen Co., of Guilford, Me., and

was done in such a simple manner that it only needs a sketch to explain it. In this case it was necessary to connect two shafts by a wide, heavy belt and have them run in opposite directions without crossing, as the shafts were too close together, to say nothing of the weight of the belt or its width, and the high rate of speed at which it must run.

It was one of those little snags that is troublesome because it is so simple you can't see through it, and might interest others as much as it did me.

* * *

HELICAL GEAR TEETH.

A. M. MORTLEY.

In March, '96, there appeared in this paper an article on helical or double spiral gearing, as it is more commonly known among pattern-makers, which interested me very much.

The reason that helical gearing is not more generally in use is from faulty construction of tooth and manner of moulding. The

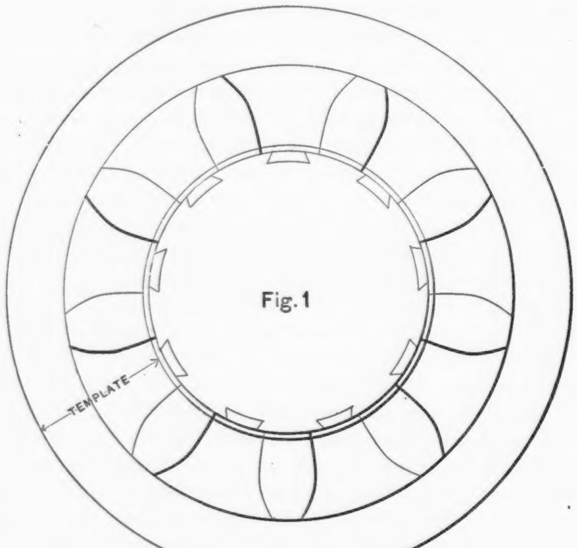


Fig. 1

gentleman, in his article, says that too large an angle produces wedging; such, I think, is not the result of the angle at all, but from the reasons stated above. I have constructed wheels with the angle greater than the pitch, and wheels ran very smoothly.

There is one error that mechanics make in laying out double spiral gears, and that is they work under laws governing spur gearing, namely: there is a law governing the pitch of a wheel of a certain size; you must have a certain number of teeth, beyond which you cannot go. I believe any mechanic will understand what I mean.

It is different with double spiral gearing, there being hardly any limit to the pitch. To make my point more clearly understood, take a wheel of a certain size, with the limit of pitch 2¼ inches, straight face, it being impossible to increase the size of wheel. Your wheel does not work satisfactorily, because of too many teeth; but, having reached the limit of pitch, you are at a standstill.

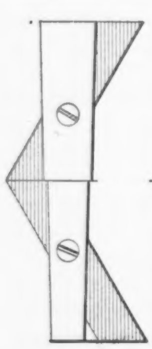


Fig. 3

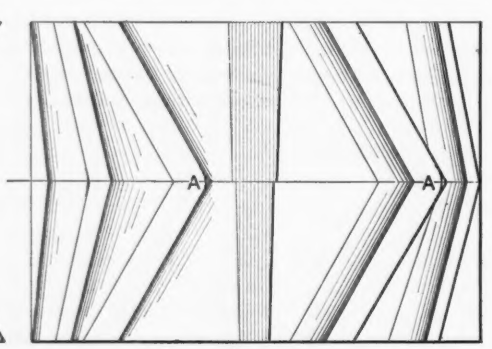


Fig. 2

Now take the same sized wheel, make it double spiral, and you can increase the pitch to 3 inches; make the angle equal to pitch on a 6 inch face, and if error stated above does not creep in, it will work perfectly. I have demonstrated this time and again. I make all my gears with the angle equal to pitch. While employed in Pittsburg, Pa., I made it greater, but adopted the former as easier to keep a record of and maintain uniformity.

The manner of moulding has much to do with the working of the above described gear. The gentleman, in his article, says that they are difficult to mould, being twisted from the sand. This I claim to be the cause of most, if not all, of the trouble, providing the drawing has been correctly made. Too much of the laying off has been left to the pattern-maker, and he, not knowing any of the laws governing the matter other than "a tooth's a tooth," makes an imperfect wheel, and it would wedge were it a straight face.

When serving my apprenticeship I worked beside the gentleman who claimed the patent on this style of gear. In Pittsburg it was formerly called after him, and the manner of moulding was the same as described by Cisnarf.

About ten years ago I adopted the plan of moulding as shown in illustration. The lay-off, as stated by your correspondent, is just the same as spur gearing, but instead of fastening the teeth to the body, I use a dove-tail; for convenience in laying off teeth, I part the pattern in the center, though it is not necessary, and have made them without doing so, but in moulding I fasten the two parts together. Of course, the tooth is made in two pieces, as shown in Fig. 3.

It will be noticed that the small end of upper half is a trifle larger than upper end of lower half. In order to allow the lower to start readily and pass through the space vacated by upper half, when body is driven out; in the old style of moulding the flask had to be parted in the center, or rather that is the way it was done.

When parted in the center, if, in closing, the moulder was in any way careless, the result was an imperfect casting at a point

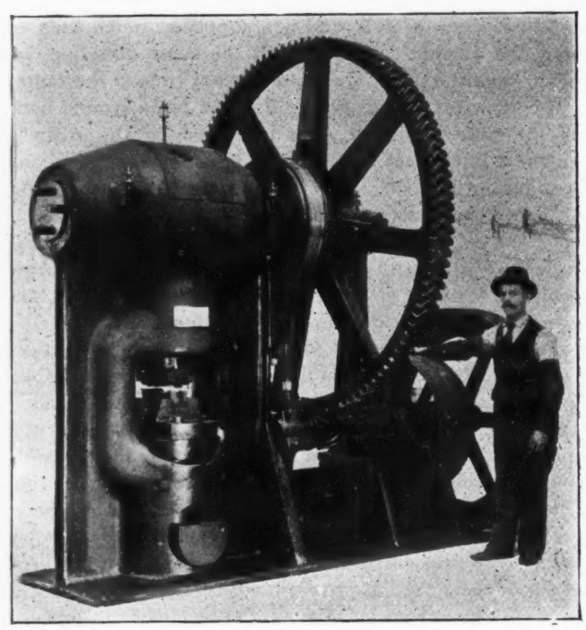


FIG. 4.

that affected it the most—at the center. In driving or twisting from the flask, the tooth pressed against the sand so hard as to destroy the shape and size of tooth. In the plan I use, the casting is just as perfect as the pattern.

In making my patterns I use cherry dove-tail and soft pine teeth. After teeth are finished the two bodies are then fastened together; a template is then made as shown in Fig. 1, fitting flask and running to within ⅛ inch of body. This fits against end of tooth and prevents them moving. A plug is now placed on body and with one blow it is driven through the template, leaving the teeth in sand, to be drawn out at leisure.

Plenty of draft can be given the body, the diameter of pitch line on each end being the same. I have used this plan on internal gear as well and found perfect satisfaction. By this method, point of tooth can be rounded as shown at A, Fig. 2, and save chipping, if gear working into it should have inside corner filled, which is often the case.

[The half-tone, Fig. 4, is a forging press built by the Ottumwa Iron Works, Ottumwa, Ia., which gives a working example of the helical gears as built by the method here described.—ED.]

MY BACKWOODS PROFESSOR.—3.

JONATHAN JONES, JR.

SOMETHING ABOUT LINES AND ANGLES.

"Well of all the blankety blank blank fools I ever saw, it's that Mr. Brown. Must think we're mind readers here instead of machinists. Brings us a little chunk of a pulley rim and want us to make another pulley like it. How in blazes does he 'spose we know what the diameter was before they smashed the blamed old pulley anyhow. Bet 'twas a trick of young Harry Brown's to see if he could'nt stick us—and I guess he has done it too—for I don't know how to find the original diameter unless I lay the chunk thats left on the floor, work around it and keep moving the old thing till I get clear around, and then—well I'd probably have to guess at it anyway. I'll ask—"

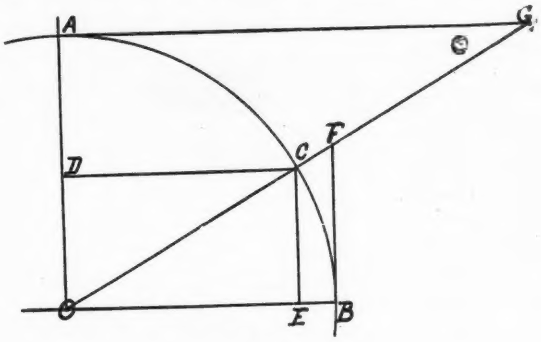


FIG. 1.

I was just going to ask Josiah when he wanted to know what I was growling about, anyway. It was a hot July day—I was hot, too—to think of the job I had to tackle, and not knowing how to go at it, but Josiah said: "When you cool off a little I'll see if I can help you out. Is Brown in any hurry for the new pulley?" As it was'nt going to be called for until the next month, Josiah said: "I'll show you a little about lines and angles before we touch this job, then you'll know how next time, yourself—if you don't think more about going fishing than you do remembering what I tell you." So we hunted a cool corner, Josiah got a new sheet of zinc, his dividers, scale and a scriber and we were ready.

"To begin with, in reckoning everything of this kind, you want to consider the *radius* of the circle you're using instead of the diameter; remember that. Now taking a radius of 10 inches in the dividers and setting one point at O, we draw the part of a circle A C B; then the lines O A, O C or O B must be 10 inches. Draw these lines so that O A and O B are at right angles and O C (in this case) is 60 degrees from O A. Continue line O C indefinitely and draw a line from A at right angles to O A (or parallel to O B) until it crosses the continuation of O C at G. Draw D C parallel to O B, E C parallel to O A and B F, also parallel to O A from point B to meet line O G. Now we have a lot of lines, but no names for them; let's name 'em.

"The part of a circle A B is an *arc* (so is any part of a circle.) A *chord* is a straight joining extremities of an arc, as A B in Fig. 2. O B and D C are *half* chords, supposing the arc to be continued on the other side of O A.

"The part included between two radii and an arc is a *sector*, as A O C or C O B. The part between a chord and its arc is called a *segment*, as A D B in Fig. 2 or in Fig. 1; A C D is half the segment. A *tangent* is a line which touches a circle without cutting it, as A G. The length of the tangent is governed by the arc, thus A G is the tangent of the angle A O C; a lesser angle would have a shorter tangent.

"In considering these lines a quarter circle or quadrant is meant, and the angle remaining between the one being considered and 90 degrees is called the complement. In Fig. 1 C O B is supplement of A O C, or vice versa, according to which angle is being considered.

"The line C E, which is at right angles to O B, and dropped from the point where the angle cuts the circle, is called the *sine* of angle C O B.

"The *co-sine* is the part of radius between sine and center, as E O or C D is co-sine of angle C O B. You should also note that the co-sine of one angle, as D C, is the sine of the complement, or remaining angle of the quadrant for C D is *sine* of angle A O C or *co-sine* of angle C O B. The part E B is called the *versed sine*, and is the distance between the foot of sine and the arc, or the radius minus the co-sine, as you can readily see that the co-sine O E plus the versed sine E B equals the radius. The *co-tangent* is the tangent of the complement of the angle, and F B is then the co-tangent of the angle A O C and tangent of C O B.

"The line running from the center of circle to end of tangent is called the *secant*. The *co-secant* is the secant of the adjoining angle, as B F."

"Of course you'll have to write them down, Jonathan, and after you draw a sketch and letter it I'd just note it down this way:

B F = tangent — tan. of angle C O B,
A G = co-tangent — co-tan. of angle C O B.
C E = sine — sin. of angle C O B,
C D = co-sine — co-sin. of angle C O B,

and so on. The abbreviations show the way they are written in Haswell and other pocket-books. Guess I've given you enough of the theory, now for a little practice."

"But say, Josiah," I interposed, "isn't that what they call ge-om"—

"Careful, my boy; better call it just lines and angles, it won't seem half as hard to you, and when we find the diameter of that pulley you'll see its uses. However, let's see what relations these parts bear to each other on this sheet of zinc, then may be you'll believe the figures we get later.

"All the figures given in Haswell, which you've puzzled over at times when you thought I wasn't looking, give the value (or length) of the different lines when the radius is 1—no matter what—inches, if you are working in inches; feet, if all your figures are feet; or miles, if you are laying out large tracts of land. We're working in inches and have a 10 inch radius, so we multiply all our results by 10 before we measure to see if they are correct.

"Take first our angle C O B, which is 30 degrees. Haswell says: 'Tangent of 30 degrees angle is .57735, co-tangent 1.73205. Multiply these by 10 and we get 5.7735 and 17.3205 inches for tangent and co-tangent; measure F B and A G and see how nearly right we have drawn it.' Now take secants and Haswell says: '1.1547 and 2 for co-secant.' Multiply by 10 and we have 11.547 and 20 inches. Measure O F and O G and see if they agree. Turn to sines and co-sines and we find .5 and .86603. Multiply by 10 once more and we have 5 inches and 8.6603 inches respectively.' Guess you're satisfied now that the fellows that calculated those tables knew their business; now let's tackle that pulley.

"After learning about the different lines and their relation to each other, the next thing is to know how to apply this knowledge in practical use, as the test of all knowledge is its use in our daily work, Brown's old pulley for instance. Let the broken piece of the rim be represented by Fig. 2, and taking a straight edge or straight piece of board, we mark off any distance, such as 6 feet, calling the points A B and marking them on rim. Mark a point at the center as C, and using a triangle or square on the board, mark D on the rim. Measure C D and in this case it proves to be one foot. You know by the zinc plate, Fig. 1 (if you half listened) that this distance C D is the versed sine of the circle, same as E B on the zinc, and that A B is the chord and we have the formula that

$$\text{Diameter} = \frac{(\tfrac{1}{2}\ Cd)^2 + V^2}{V}$$

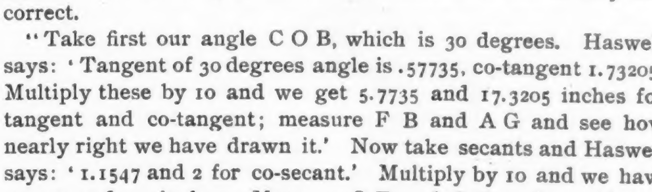


FIG. 2.

As Cd = the chord A B, and V = the versed sine, we can get to work by substituting our known values in the formula, and we have

$$\text{Diameter} = \frac{(\tfrac{1}{2} \text{ of 6 feet})^2 + 1^2}{1}$$

Tackling the portion in brackets first, we have ½ of 6 = 3, 3^2 (multiplied by itself) = 9. Then $1^2 = 1$ and $9 + 1 = 10$ feet, the diameter of the pulley.

"Suppose Brown had sent another pulley which was smaller and we would perhaps use a rule 10 inches long for the chord A B, the height C D (or versed sine) is .8 of an inch, what is the diameter?

$$\text{Diameter} = \frac{(\tfrac{1}{2} \text{ of } 10 \text{ inches})^2 + .8^2}{.8}$$

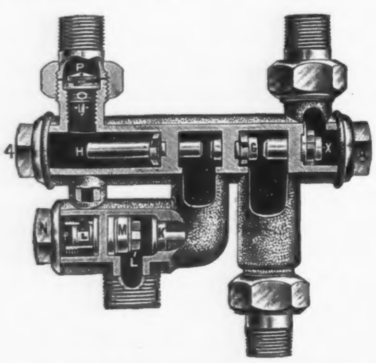
$\frac{1}{2}$ of 10 = 5, 5 squared = 25; .8 squared = .64; 25 + .64 = 25.64 ÷ .8 = 32.05 inches as diameter of pulley.

* * *

A NEW INJECTOR.

We illustrate herewith an improvement in automatic injectors especially designed for boilers carrying very high steam pressures, or with ordinary steam pressures of 75 to 125 pounds to handle a very hot water supply.

It has always been considered impossible with an automatic injector to obtain a wider working range than from 20 to 25 pounds low pressure up to 145 to 155 pounds high pressure, with an ability to handle hot water at 120 to 125 degrees at 60 to 80 pounds steam pressure, and 95 to 100 degrees at 125 pounds steam pressure. With the improved injector here illustrated, there is obtained a working range of from 15 pounds low pressure to 250 pounds high pressure, and at the same time an ability to handle water at 140 to 145 degrees with 65 to 85 pounds of steam; 135 to 140 degrees at 100 pounds of steam, and 119 to 122 degrees at 150 pounds of steam. A reference to the cut will show that the construction of this injector is entirely different from that of any other injector on the market.



It will be noticed that there is an outlet from the chamber in which the delivery jet H is located, and which is termed the pressure chamber, around the valve L to the overflow, while in every other injector ever made there is no outlet from this chamber except into the boiler. In starting this injector, therefore, the only pressure to be overcome is the atmospheric pressure, the water passing through jet H into the pressure chamber and then out around the valve L, which gradually closes, as the current to the boiler is established; this valve being thereafter held to its seat by the full boiler pressure in the pressure chamber referred to, which also acts through this valve upon the valve K, as when both the valves L and K are seated, the end of the valve L comes against the end of the valve K, holding it firmly to its seat by the back pressure from the pressure chamber referred to, thus accomplishing automatically that which in positive injectors requires two or three valves to be operated by the engineer in charge. This form of construction enables the injector to handle a very hot water supply and still be automatic.

This injector is being placed on the market in the United States and Canada by the Penberthy Injector Co., 12 Seventh street, Detroit, Mich., who have purchased the rights for these two countries from the International Specialty Co., having much improved the construction of the machine over the original form in which it was placed on the market by that company, something over a year ago.

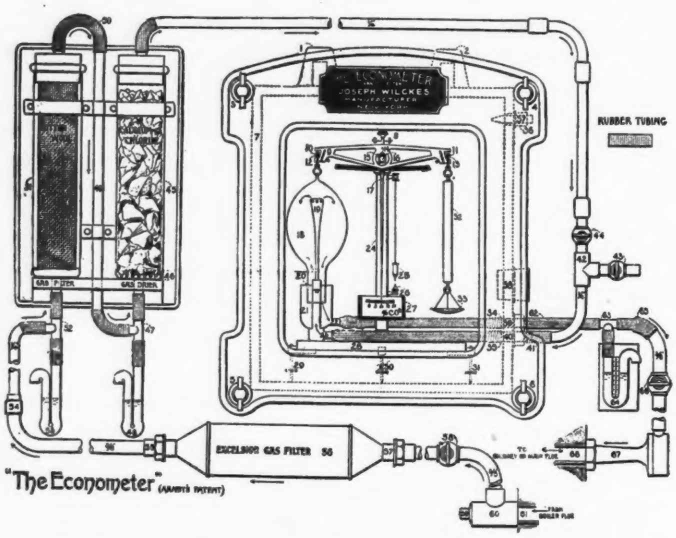
* * *

THE ECONOMETER.

This instrument is the invention of M. Arndt, and was devised for measuring continuously and automatically the percentage of carbonic acid in the gases, showing the conditions of combustion. This is based on the fact that, as carbon is the principal ingredient in fuel, and as carbonic acid is formed by the combustion of the carbon with the oxygen of the air, so the less the surplus of air conveyed to the furnace, the larger the volume of carbonic acid in the gaseous smoke.

All air admitted beyond the necessary amount causes a direct loss of heat. There are no visible signs of the fire being supplied with a surplus of air, the fire giving no indication. As the extra air is brought to the same high temperature of the gases which leave the boiler, a loss of heat occurs which is to be avoided if possible. The percentage of carbonic acid contained in and mixed with smoke gives a guide to the amount of surplus air, and this fact is taken advantage of by this instrument, which shows on scale 27 by pointer 17, and tells whether there is a surplus of air or not.

The "Econometer" is a gas weighing machine on an entirely new principle, fixed in an air-tight case 7 with a plate of glass in front. In the case 7 there are two connecting joints, 39 and 40, 40 is connected by a pipe of about $\frac{1}{4}$ inch bore to the flue of the boiler between the latter and the damper, and 39 is connected by a similar pipe to a small aspirator in the flue between the damper and the chimney, or the chimney itself, and which is worked by the draft of the chimney. In the interior of the "Econometer" case 7, the joint 40 is connected with the ascending pipe 23, and the joint 39 with the descending pipe 22 by means of india rubber tubes 34 and 35.



"The Econometer"

The gas weighing machine itself consists of a very finely adjusted, highly sensitive balance, to which is fixed the pointer or index 17. One one end of the balance is suspended an open gas reservoir 18, with a capacity of about a pint, and the opposite end a compensating rod 32, to which is affixed a scale with a number of glass beads, by which the gas holder can be balanced. The knife-edges of the balance are steel gilded, and the caps are agate. The whole balance works on a pillar screwed on a cast plate 28. The latter has adjusting screws by which the balance is finely adjusted, both horizontally and vertically. For this purpose a small pendulum is attached to the supporting pillar. Further, a frame 27 is fixed on the pillar in which is inserted the scale. The scale is interchangeable, so that other gases may be weighed.

The gas-ascending pipe 23 reaches into the gas-holder or reservoir 18, which has a neck 20 open below and surrounded by the outgoing connecting joint 21 open above. The neck 20 has free play round the pipe 19, as well as around the connection 21, so that the gas balance can swing free from resistance, and therefore works with extraordinary exactness.

The combustion gases having to pass through filters and drying chambers, enter the weighing globe thoroughly cleaned and dried.

As carbonic acid is about 50 per cent. heavier than atmospheric air and the other gases contained in the gaseous smoke, so the gaseous smoke which continually fills the reservoir must be heavier in proportion to the amount of carbonic acid contained therein. The scale 27 is so divided that the movement of the pointer 17 of the gas-balance from one dividing line to another corresponds with the volume per cent. of CO_2 in the gaseous smoke to be weighed. The amount of carbonic acid in the gaseous smoke can therefore be read off at all times. For further particulars apply to Joseph Wilckes, 106-108 Fulton street, New York.

* * *

At a meeting of the Baltimore members of the Association of American Draftsmen, at No. 11 St. Paul street, Thursday evening, May 20th, a local chapter was organized. The following officers were elected: Mr. James W. Lee, of the United States Revenue Cutter Service, President; Mr. W. T. Hoofnagle, Vice-President; Mr. E. A. Osse, Secretary; Mr. W. H. Roes, Assistant-Secretary, and Mr. D. D. Thomas, Jr., Treasurer.

HOW AND WHY.

A COLUMN INTENDED TO CONTAIN CORRECT ANSWERS TO PRACTICAL QUESTIONS OF GENERAL INTEREST. GIVE ALL DETAILS AND YOUR NAME AND ADDRESS, WHICH WILL NOT BE PUBLISHED UNLESS DESIRED.

31. H. W. B. Which coal, anthracite or bituminous, will give the best results in a Babcock & Wilcox boiler, with a grate surface of 7 by 4 feet? *A.* There is very little difference. All the difference there is, is in the matter of cost of the coal. There is no way of determining the matter except by trial.

32. H. W. B. Is the eccentric motion more even than the crank; also, why is it not more used on engines in place of the crank? *A.* The motion from an eccentric is the exact equivalent of that from a crank. The reason that it is not used in place of the crank is because it is more costly to make and maintain, and there is greater loss from friction in its operation.

33. J. E. P. Can you give me a simple test for lubricating oils? *A.* There is no test so simple or so conclusive as that of actual trial. Measure the power for definite power with different oils.

34. H. O. A. writes: I wish to build a vertical engine and want to know the dimensions of the cylinder, length and width of ports I want the engine to be 1¾ to 2 HP., steam pressure 100 lbs., 300 revolutions per minute. *A.* Calculations on such small engines are seldom very satisfactory, but probably the following dimensions will answer your purpose: Cylinder, 2¾ inches bore by 4½ inches stroke; steam port, 2 x .3 inches; exhaust port 2 x .6 inches; outside lap of valve .25 inch; inside lap .05 inch. Make travel just enough to open ports, about 1.2 inches. This is calculated on a mean effective pressure of half the boiler pressure.

35. R.T.G. writes: In looking over a catalog I find a drill gauge described as having an angle of 59 degrees, "the correct angle for grinding twist drills." What does this mean? *A.* It means that the writer thinks an angle of 59 degrees *on each side of the center line*, or a total angle of 118 degrees, is the correct angle for twist drills. We should advise 60 degrees on each side or 120 degrees total, for easy reckoning and remembering, and do not believe the difference would ever be noticed in practical work. Different work requires different angles, brass workers grinding to drills much more acute angles than when they are to be used on iron or steel. The angle given, 59 degrees (or 60), is for general use, and is the angle on each side of a line running through center of drill.

36. R. B. S. wants to know whether high carbon or low carbon steel is best for gauges. *A.* Inquiring among makers reveals a difference of practice, some using high carbon steel for their best gauges and low carbon steel for ordinary work. Others use low carbon steel entirely, having found difficulty with the other, it being very apt to change shape somewhat. They claim, however that the low carbon steel can be hardened as well as the other, and gives results which are equally satisfactory.

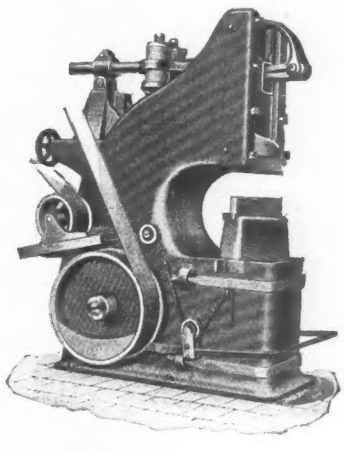
37. F. B. asks: In calculating the speed of shafting, should the thickness of the belt be considered? *A.* In ordinary calculations the belt is omitted. It is claimed by some of our correspondents that for exacts calculations, the thickness of the belt should be added to the diameter of the pulley, or the diameter of pulley considered to be from the center of the belt's thickness on one side, to the center of thickness on the other side. 2. What pressure can five men put on the screw of a straightening press, lever 2 feet 6 inches long from center of screw to end of lever, (a double wrench), 3 threads to inch on screw. *A.* It is evident that the power at end of lever travels through the circumference of circle with a 30 inch radius or 60 inch diameter, which is $3.1416 \times 60 = 188.496$ inches. The power then moves 188.5 inches (practically), while the screw (which does the work) moves but ⅓ of an inch (being 3 threads to inch). As the work power equals the distance through which the power moves divided by the distance through which the work is done. Or, $188.5 \div \frac{1}{3} = 565.5$ inches, making 47.2 feet. Calling each man's power 100 pounds, we have $47.2 \times 500 = 23\,600$ pounds. Allowing 50 per cent. for friction of screw (a common allowance for ordinary screw presses or jacks), we have 11 800 pounds pressure on shaft at center of a span of 32 inches, distance between blocks under shaft. The amount of deflection in shaft can be calculated by considering it as a beam with a load of 11 800 pounds, (or 12,000 in round numbers) applied.

38. A. C. R. writes: What is the power of a cubic foot of air compressed to 1 500 pounds pressure per square inch? *A.* This means what power will a cubic foot of air, at this pressure, give out in expanding down to the pressure of the atmosphere. Neglecting all losses due to friction, etc., of engine in which this air must be used, this is simply a question of finding the work due to expansion. Taking absolute pressures and assuming atmospheric pressure at fifteen pounds for easy reckoning (14.7 is nearly exact), we have a pressure of 1 515 pounds to expand down to 15 pounds, or ($1\,515 \div 15$) 101 expansions. The table of constants for 1 per cent. cut off, gives .056 as the figure, which means that a cut-off of 1 per cent. or $\frac{1}{100}$ of the stroke will give a mean effective pressure (absolute or from vacuum) of .056 pound for every pound of initial pressure. As this expansion is a little more than this, we assume .0555 as constant. Now, imagine a cylinder whose piston is one square foot area (144 square inches) and the cubic foot of air will occupy one foot of the stroke of this imaginery cylinder. In order to expand 101 times, the air will occupy 101 times the original volume and the piston must move 100 feet. Multiplying 1 515 by .0555 gives 84.0825, deducting 15 pounds—back pressure due to atmosphere, gives 69.0825 M. E. P. Multiplying 144 sq. in. by this gives 9947.88. Multiplying again by stroke (100 feet) gives 994 688, and dividing by 33 000 gives 30.145 HP. There is a formula which will give the result direct, without assuming the cylinder, etc., but as this gives you reason for each step and will probably assist you in any similar problem, it seemed best to show the longer method.

* * *

NEW POWER HAMMER.

The hammer shown in the accompanying engraving is the latest production of R. E. Kidder, 35 Hermon street, Worcester, Mass. Among its improvements are the ability to change the length of stroke as desired, and to adjust the dies rapidly and accurately without stopping the machine.



The belt binder is so arranged that the whole weight is taken from the treadle, so that in operating the treadle the only pressure to be overcome is the resistance of the belt. When the belt stretches, the binder is taken up by means of the chain, which connects the binder so that the same motion of the treadle bar is always maintained. The brake (not shown in cut) is automatic and takes very little power to operate. The strap can always be kept at the proper tension by means of the sector and worm.

The machine requires but little power for its capacity. The helve is cushioned by four large rubber springs, which, in combination with the strap, give a very elastic blow.

The machine is carefully designed for the work it has to do, is well made of such material as is best adapted for the various parts, and is made in six sizes, with heads ranging from 25 to 200 pounds. The machine with the 100 pound head weighs 4 000 pounds.

* * *

AUTOMATIC DROP PRESS.

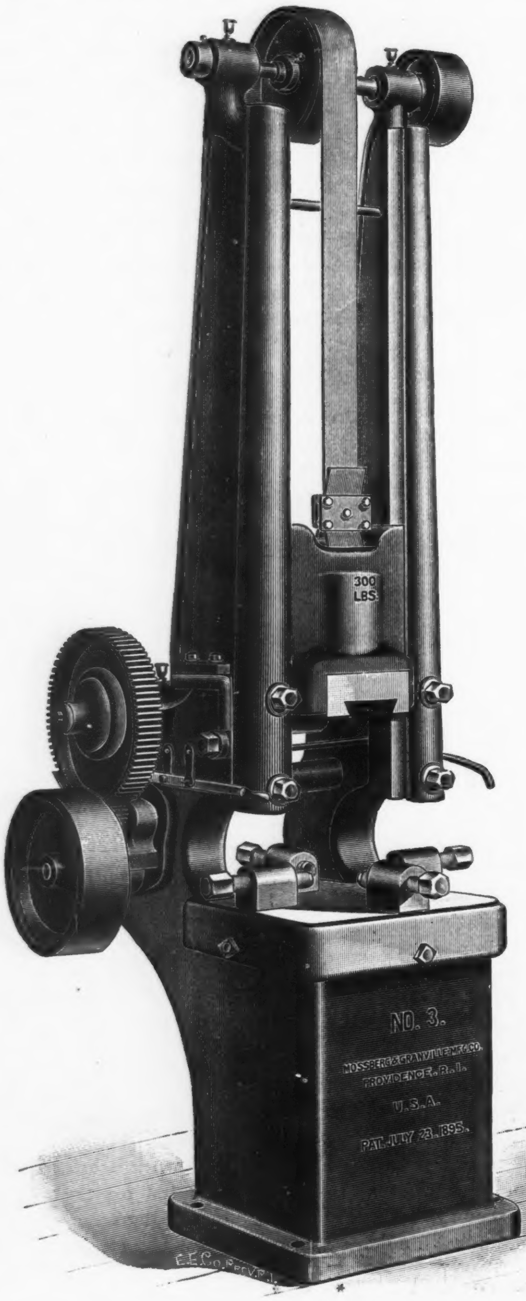
The following illustration represents a new design in Automatic Drop Presses, which is easy to adjust and operate, also capable of producing uniform work. They can be used to advantage for forging, flattening and manufacturing a large variety of hardware novelties.

These presses are self-contained, all driving mechanism being fastened to the base where it is easy of access. They are operated in the same manner as a board drop, either with foot or hand trip. The construction of the guides, support for the crank shaft, offers ample working space for the operator. The guides for the hammer are substantially fastened, and cannot be thrown out of line by strain or vibration. The left guide is detachable, so that all wear may be taken up. All bearings are fitted with

bronze bushings which can be renewed when worn. In the larger sizes roller bearings are used.

The length of stroke can be quickly changed by varying the length of the crank motion. The dies are easily adjusted, the flange pulley being turned by hand to raise and lower the hammer during the setting; in the larger sizes, a bar is provided. When power is applied to this machine, the hammer is raised to its gauged height The clutch in then automatically thrown out, leaving the hammer suspended, securely locked in that position, until released by the trip lever when moved by the operator.

The clutch mechanism plays an important part in the action of this press, and acts immediately as the hammer rebounds from the die. A die holder keyed into bed, or poppets, are furnished



AUTOMATIC DROP PRESS.

as ordered. The poppets are made of forged steel and the screws are crucible steel well finished, hardened and tempered.

On medium sized work placed in position in the dies by hand, the capacity of this style of drop press is from 15 to 20 000 finished pieces per day (of 10 hours), according to the character of the work and the skill of the operator. On the smaller sizes, automatic feeds can be furnished which will more than double the capacity of these machines.

The proportion of weight of hammer, to weight of base is 1 to 16. This style of drop press is much used for the manufacture of spoons, forks, medals, name plates, jewelry, solid silver ware, flat ware, watch, clock and stamped brass work, drop forgings, gun and pistol forging, steel plows, agricultural implements, carriage and bicycle forgings, edge tools, household, ship and saddlery hardware, skates, cutlery and lock work.

These presses are made in ten sizes with hammers varying from 25 to 1 200 lbs. by the Mossberg & Granville Mfg. Co., Providence, R. I.

* * *

GRIBBEN'S COMPOUND INDEX MOVEMENTS.

As we frequently have inquiries concerning Mr. Walter Gribben's table of compound indexing movements, it seems best to answer them by publishing the table, which Mr. Gribben has kindly furnished us:

TABLE OF COMPOUND INDEX MOVEMENTS ON THE BROWN & SHARPE UNIVERSAL MILLING MACHINE.

No. of Teeth.	Movements.	No. of Teeth.	Movements.	No. of Teeth.	Movements.
69	$\frac{21}{23}-\frac{11}{33}$	154	$\frac{8}{21}-\frac{4}{33}$	273	$\frac{21}{49}-\frac{11}{39}$
77	$\frac{9}{21}+\frac{3}{33}$	174	$\frac{11}{33}-\frac{3}{29}$	276	$\frac{11}{23}-\frac{11}{33}$
87	$\frac{23}{29}-\frac{11}{33}$	182	$\frac{3}{39}+\frac{7}{49}$	287	$\frac{14}{43}-\frac{6}{41}$
91	$\frac{6}{39}+\frac{14}{49}$	186	$\frac{17}{31}-\frac{11}{33}$	288	$\frac{5}{20}-\frac{2}{18}$
93	$\frac{3}{31}+\frac{11}{33}$	198	$\frac{3}{27}+\frac{3}{33}$	294	$\frac{23}{49}-\frac{18}{39}$
96	$\frac{3}{18}+\frac{5}{20}$	225	$\frac{5}{18}-\frac{2}{20}$	297	$\frac{2}{33}+\frac{2}{27}$
99	$\frac{15}{27}-\frac{5}{33}$	231	$\frac{3}{21}+\frac{1}{33}$	301	$\frac{18}{43}-\frac{14}{49}$
105	$\frac{8}{21}$	253	$\frac{12}{23}-\frac{12}{33}$	304	$\frac{10}{20}-\frac{7}{19}$
138	$\frac{11}{33}-\frac{1}{23}$	259	$\frac{11}{37}-\frac{7}{49}$	308	$\frac{4}{21}-\frac{2}{33}$
147	$\frac{13}{39}-\frac{3}{49}$	272	$\frac{10}{20}-\frac{6}{17}$	360	$\frac{2}{18}$

The sign + indicates that the two fractional movements between which it occurs are to be added together, or, in other words, that they are both in the same direction. The — sign indicates that the second fractional movement is to be subtracted from the first, or, in other words, that the two movements are in opposite directions.

* * *

A LITTLE ARITHMETIC.

FINDING THE AREA OF A CIRCLE—SQUARING OF A NUMBER.

The regulation rule for performing this very important operation is: Square the diameter and multiply by .7854. Another way is to square the radius and multiply by 3.1416 (called π (pi) by the mathematician). This is the same multiplier that is used in finding the circumference of a circle when the diameter is given. The first method is the one generally used, however. We are indebted to Mr. Juan de Tajeda for the following method, which shortens the problem a little, and while this may be known to some, we are sure it will be new to many. It is not claimed to be original, but being useful we do not care as to its origin. This method can be shown better than explained.

Find the area of a 25 inch pipe. Square 25 and $25 \times 25 = 625$. Multiply by 7 as follows:

```
625
  7
----
4375
 4375
  8750
   8750
--------
490.8750
```

It will be seen that the first line is simply a multiplication by 7. The next line is the same figures copied down underneath, but moved one place to the *right*. For the third line, multiply the second (or first) line by 2 and set the result down, beginning one place to the *right* as before. The fourth line is also like the third, but moved one place to the right, the same as with the second line. Add the products and point off four figures. To test the accuracy of this, try it with a pipe 10 inches in diameter. Then squared equals 100.

```
100
  7
---
700
 700
 1400
  1400
-------
78.5400
```

While this isn't so much of a short cut that it "does" itself, it is handy to remember and is a help many times.

In this connection it will be convenient to know a handy way to square any number mentally or with the aid of a few figures. Take 16 for example. Subtract it from 20 (the next higher *tens* number), this leaves 4. Subtract this number (4) from 16. leaving 12. Multiply 12 by 20 (the next higher *tens* number), giving

240. Square the difference (4) and we have $4 \times 4 = 16$. Add this to 240 and it gives 256 as the square of 16.

This may appear bewildering to many, and some have at first sight even insinuated that it took a calculating machine to do it; but this is prejudice, and a little practice will enable any one to use the rule quickly and without figures. It is used by mechanics we know, who shun algebra as they do the itch, proving that it isn't as hard as it appears.

Take 87 and square it. The next higher *tens* number is 90. Then 90 minus 87 equal 3, and 87 minus 3 equals 84. Then multiply 84 by 90 and get 7560; square 3 and get 9; add 9 to 7560 and we have 7569. With the numbers ordinarily in use, say for cylinder diameters, it is very easy, as they rarely exceed 40 inches, and it is easy to multiply mentally by *tens* numbers. In the form of a rule this would be: *Subtract the number to be squared from the next higher tens number; subtract the difference from the orignal number; multiply this difference by the tens number. Square the first difference and add to the product. This is the square of the original number.*

The rule looks formidable, we admit, but try it on a few small examples and see how easy it is. The writer has used it entirely for a number of years.

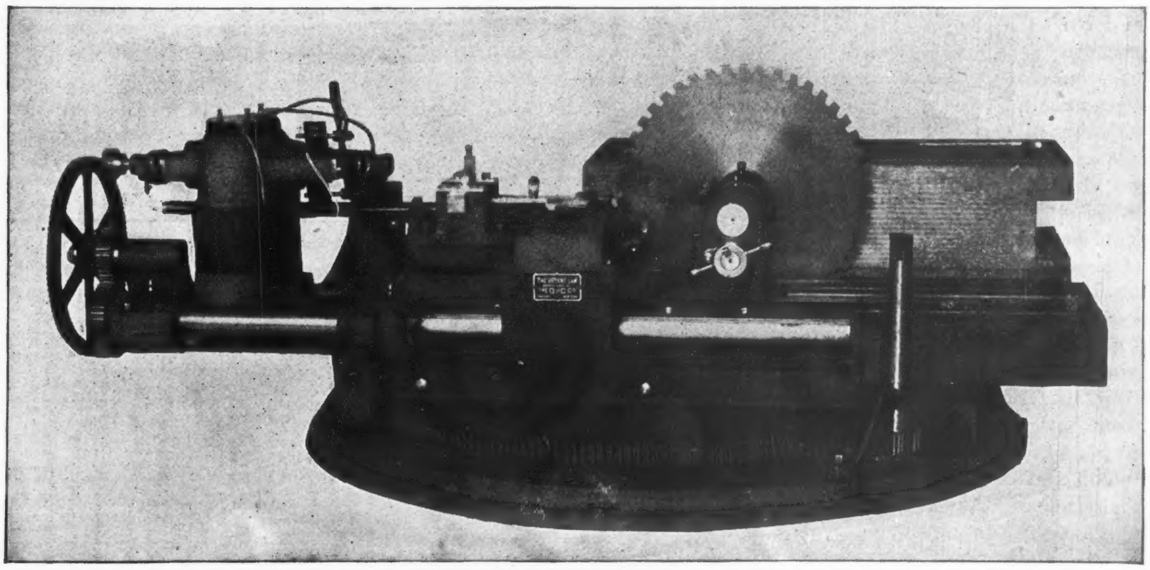
* * *

NEW POWER SAWING MACHINE.

This machine has been constructed specially for bridge builders, architectural iron works, and other metal workers handling large structural steel and other heavy metals, keeping in mind the special needs of this class of metal workers for a machine that is not only substantially and compactly built, but one which occupies smallest space and is capable of being handled with the least amount of power and with the greatest ease. It has always been the policy of the manufacturers of the Bryant saw to discuss most freely all points raised by practical men, either suggestive or critical, looking to the betterment or adaptation of these machines to practical work. In bringing out this new machine they have profited by suggestions made by some of the most practical men engaged in this work.

Among the special features embodied in the No. 15 power sawing machine, the following will commend themselves to the practical mechanic as being very valuable:

The saw is 25 inches in diameter, being amply large for a very wide range of work, and is provided with one faced side, making this machine very valuable for mitre work, and also for bridge coping, a class of work, to accomplish which, emphasizes the value of the cold saw. The advantages of lateral adjustment of saw blade, requiring but a minute to set the saw to line, are too apparent to need more than passing mention. This feature dispenses entirely with the necessity of moving heavy work, where in sawing to line, the adjustment required is less than 2 inches.



NO. 15 BRYANT SAW, WITH CIRCULAR BASE AND MOTOR.

The cam-lever movement feed, allowing the operator to change instantly from slow to fast, or vice versa, without stopping or even checking the speed of the saw, commends itself as a very valuable improvement. This machine is also provided with a stop, by which the operator can immediately throw the machine out of gear, so as to avoid danger or injury in cases of emergency. The available surface of saw blade above the arbor is 10 inches; available surface of blade to the right of arbor, horizontal with the lower table, 10 inches; height of extra table, 12 inches; the blade extending down 4 inches below the surface of the lower table.

Each machine is fully guaranteed and sent out subject to acceptance after test trial, being provided with clamps, grinder for sharpening blades, etc. Any additional information desired, will be cheerfully furnished by the manufacturers. Made by the Q. & C. Co., 700 Western Union Building, Chicago, Ill.

* * *

WHAT MECHANICS THINK.

THIS COLUMN IS OPEN FOR THE EXPRESSION OF PRACTICAL IDEAS OF INTEREST, TECHNICAL OR OTHERWISE. WRITE ON ONE SIDE OF THE PAPER ONLY, AND BOIL IT DOWN.

WHEN SKETCHES ARE NECESSARY TO ILLUSTRATE THE IDEA, SEND THEM ALONG—NO MATTER HOW ROUGH THEY MAY BE, WE WILL SEE THAT THEY ARE PROPERLY REPRODUCED.

A REPAIR JOB.

The following instance will emphasize the fact that it is well to know what the conditions will be when new parts replace old ones, and also shows the value of experience. The men who had the finishing of this job will not again be at a loss to know the trouble in a similar case if ever it should fall to them to fix it.

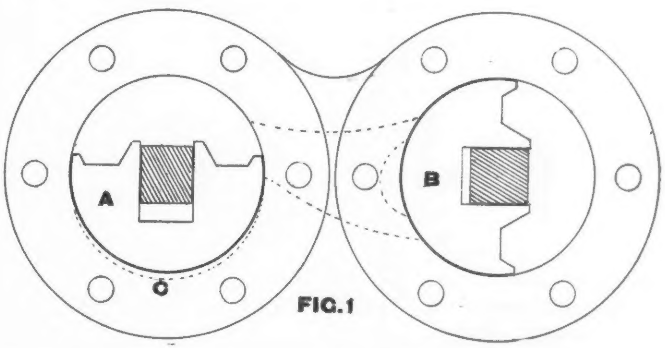


FIG. 1

The valve stems of a pumping engine supplying a city of twelve thousand inhabitants, became so badly worn from ten years' constant use that it was necessary to replace them. The valves were of the Corliss type, one main valve with an independent cut-off. They were in good condition, as were the seats; these, however, were worn down about one-eighth of an inch below the original surface, but were comparatively smooth.

The new stems were made and grooves in valves nicely planed out to make a close fit. When the parts were again assembled, trouble was at once experienced. With every revolution was heard the harsh grating sound of cutting surfaces, accompanied by a bad blow in the exhaust. As a water supply had to be accu-

mulated, it was necessary to run. After thirty-six hours of service one of the valve stems $1\frac{1}{4}$ inches in diameter at the neck twisted off, giving some notion of the tremendous stress necessary to move the valve. On removing the bonnets the trouble was found to be that the valve had worn down and still maintained nearly its original curvature, so that the axis of rotation was below that of the valve stem. Fig. 1 and the centers moved eccentrically. The parts being so closely fitted no adjustment was allowed, and valve thereby was forced from its seat at the end of each stroke. An old stem was hastily fitted in place and engine run until time could be taken to replace it, then the chambers were bored out on the seat to a radius slightly larger than the original, and valve turned to fit. The stud holes in bonnets were cut out to allow center of stem to fall to that of valve, and when the parts were again assembled no further trouble was experienced.

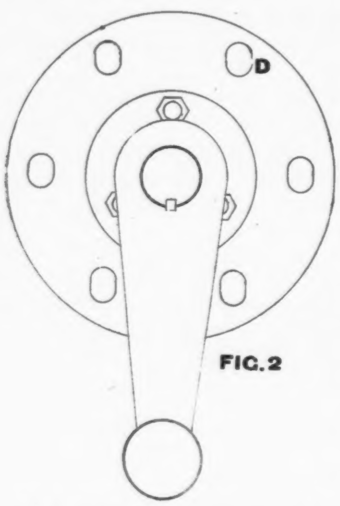
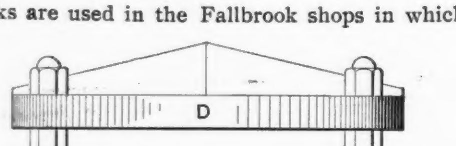


FIG. 2

HYDRAULIC JACKS.

A number of jacks are used in the Fallbrook shops in which water under a head is used instead of compressed air. For forcing in brasses, bushings, etc., the water pressure has its advantages, as it is under control, and the amount and suddenness can be graduated to a nicety. The size of the piston is such that with each ten pounds registered on gauge, a pressure of about one ton is obtained on ram, and with the available pressure in the city mains a total of ten tons can be realized. One is sunk in the floor to the top of cylinder, and makes a convenient tool for pressing in crown brasses.



In construction the cylinder is cast with one head and piston with rod. Top and bottom are connected with four $1\frac{1}{4}$ inch rods. A pressure gauge and two globe valves make it complete.

A FEW SHOP TOOLS—CHUCK JAW—"WAY" OILER—BORING TOOL.

In Figs. 1 and 2 are shown views of a chuck jaw for independent chucks that is useful for some classes of work, such as rings, castings for packing rings, and other pieces of similar nature. Thin bushings can be firmly held without springing, and it does away with the necessity for internal bracing.

The main jaw A is moved in the usual manner by the screw, and it carries the auxiliary jaw B and screw C.

In chucking a ring it is gripped between the two jaws by the screw C and then moved in or out by the main screw to the correct position, then the other jaws are gripped, doing away with a great deal of the tightening and loosening of jaws to bring piece to place. Segments are also readily held and quickly chucked to any radius within its capacity. Ordinary work can be held in the usual manner so that a chuck thus equipped is not necessarily a special tool.

Fig. 3 shows a "way" protector for lathes, that is in common use in some shops and unknown in others. It serves the double purpose of brushing off dirt and chips and keeping the ways well oiled. The under side is cored out, forming the cavity D, which can be filled with saturated waste or hair. A hinge allows it to be turned up for oiling.

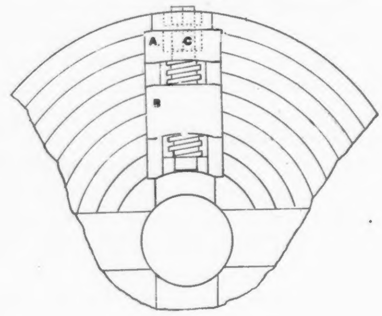


FIG. 1

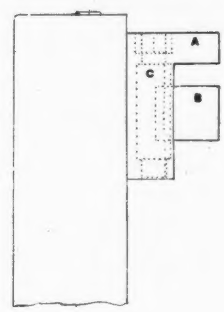


FIG. 2.

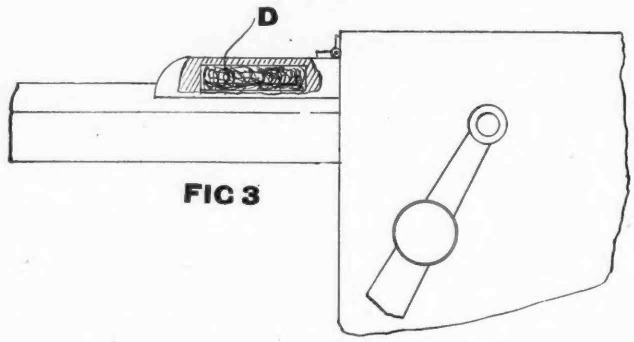


FIG 3

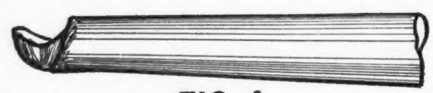


FIG. 4

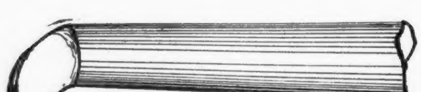


FIG. 5

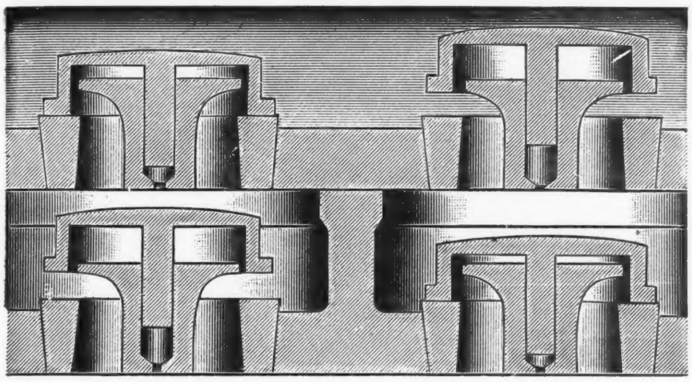
Figs, 4 and 5 are views of a form of boring tool observed on the lathe board of a German mechanic. The peculiar form of lip is hard to show on paper, but the surprising way it has of curling out chips in wrought iron or cleaning out a generous amount from cored holes in hard castings, will convince the observer that there is something in it. FRED E. ROGERS.

Corning, N. Y.

POINTERS ON PUMPS.—VI.

THE MARSH PATENT EASY-SEATING WATER VALVE.

Our new water valve as shown herewith is, like the other features of the Marsh pump, simplicity itself. It consists of a cup-shaped valve with central guiding pin, and a valve seat and disc cast solid as shown in cut. This disc is slightly larger than the aperture below it in the valve seat, and causes the fluids pumped to be deflected at right angles, just the same as an ordinary water valve does with its lift limited by a stop. The fluids therefor have power to raise the valve as high the disc only, and for that reason a stop to limit the lift of the water valve is not necessary.



SECTIONAL VIEW OE EASY-SEATING WATER VALVE.

This is the only water valve used in a pump that does not strike against a stop in its upward movement. When it closes it does not seat with a harsh abrasive action like other valves, but being partially cushioned on the water between the disc and valve, it seats softly, and we believe it is the most durable and satisfactory water valve ever devised. The waterways are large and the valve has capacity equal to any other. This water valve is patented, and is used only in the Marsh steam pump.

Write us for our new catalogue, which contains a large amount of valuable information for steam users.

THE BATTLE CREEK STEAM PUMP Co., Battle Creek, Mich.—*Adv.*

A BLACK DIAMOND FILE.

"You seem to have some kind of a treasure there?"

The gray-haired old blacksmith had put the bulk of his tools carelessly away on their customary shelves, but one article he had wrapped in paper. About to deposit it in a corner of a chest with a stout lock, he halted the movement with a smile.

"I have," he nodded, "of the rarest kind."

"A momento, a keepsake, eh?"

"No, an old friend."

"Looks like some kind of a tool?"

"That's just what it is—A Black Diamond File."

He drew it out from its covering now, and he eyed it and he fondled it as if both memory and service had indeed endeared it to him through long association.

"A kind of tool," he repeated, softly. "It is the kind you don't run across everywhere in these cheap, quick days, when everything goes, the kind that was made honest and acts honest. Once in a while an old fossil like me runs across an idea and clings to it like moss. This file is one of them. See here. In comes a man with a tool. It is new and pretty. It's this, it's that, everything that is right, he says. I get dazzled and buy, whack! comes a blow and the tool breaks. This one does not. I bought that file on a representation that's held out. First, they said it would cut, and it cuts. They said it would last, and it last. They said it was standard. It's all that. When I have a friend that don't bend before a storm, and helps me through hard tugs and soft tugs alike, that stands every test and comes up smiling, what do I do? Treasure him, cherish him, treat him well, don't I? Well, that is the case here. I'd keep that old tool in velvet if it would show my appreciation any better. It is like having a friend and treating him as such. My temper-keeper is my "Black Diamond File." — *Chicago Journal of Commerce.*

* * *

THE popular Providence line of steamers between New York, Providence, Boston, Worcester and all points North and East, has resumed its passenger service for the season. This is a very desirable route for travelers who have occasion to visit Providence, Boston or other points as passengers are assured a full night's rest with early arrival at destination. An excellent orchestra, first-class cuisine, careful and attentive employes combine to make this line the favorite route for all lovers of comfortable travel. Steamers "Massachusetts" and "Rhode Island" leave New Pier 36 N. R. at 5.30 P. M., due Boston at 7.15 A.M. Train for Worcester and all points North leaves at 6.35 A.M. During the summer season connections are made and through tickets sold to White Mountain points, Bar Harbor and all the Eastern summer

resorts. A delightful feature of this line is the sail through Narragansett Bay and Providence River in the early morning or evening.

* * *

MANUFACTURERS' NOTES.

LANDIS BROS., Waynesboro, Pa. write us that the business interests and the patents issued to Mr. A. B. Landis will hereafter be controlled by the Landis Tool Company, a corporation organized since the destruction of the works, with an anthorized capital stock of $100,000, $50,000 of which has been paid in in cash. All communications with reference to their line of manufacture should be so addressed. With increased facilities the new company will be in position to serve its friends in the best possible manner. Mr. A. B. Landis has been retained as superintendent and mechanical engineer of the new company.

THE DAVIS & EGAN CO. report a general improvement of trade in the Northwestern part of the United States, their Chicago house having taken some very nice orders during the past two weeks. Their foreign business continues on the boom, Mr. Davis having just sent them orders for $30,000 from Antwerp, Stockholm and Copenhagen. They report trade in England as not seeming quite so brisk as it was 60 days ago.

A RECENT decision in the suit of the Consolidated Safety Valve Co., against the Ashton Valve Co., held that the Ashton valve did not infringe the patent of Geo. W. Richardson. The court held that the proper construction of the Richardson patent requires that the aperture at the ground joint caused by lifting the valve should always be greater than the aperture for the exit of steam into the open air.

FRESH FROM THE PRESS.

Intermittent Gears and Bevel Gear Chart. Frank Burgess, Boston Gear Works, 31 Hartford St., Boston, Mass. 50 cents.

The author says: "As there is no other treatise on the subject of intermittent gearing, this is offered to give some light on a subject which may be found of much value, in that it will assist in reducing complicated movements to a simple form of gearing, which will still give the same results."

This is a very interesting subject, and designers of automatic machinery, as well as those who have aspirations in that direction, cannot afford to be without this book, which, though small in size, contains much information and many suggestions which are of value to any mechanic who is interested in this class of work—a class which alway inspires admiration, even from non-mechanics.

Electricity and Water Power. Mark A. Replogle. Electrical Review Publishing Co., New York. $1.00.

This is a well made little book of 161 pages, of a convenient size for the pocket of the busy man who is interested in this subject. It is not intended as a scientific treatise, but as a little work which will prove helpful to the general reader by acquainting him with the principles involved, the machinery used and the plants that have been installed. It contains illustrations of the Niagara Falls plant and other water-power stations which are in successful operation.

Hot Water Manual, by Walter Jones. Daniel Stern, publisher, Chicago, Ill. 220 pages; price not given.

This is a reprint of articles which appeared in the *Ironmonger* of London, and judging from the typography and illustrations, many of the original plates have been used. The author evidently knows what he is talking about and gives much information on the various heating systems, with the good points of all as well as their advantages. While this represents English practice more than American, as far as the heaters go, the information is of almost equal value on this side of the pond. Anyone in the heating business will find much of interest in it.

Aluminum. Pittsburgh Reduction Co., Pittsburgh, Pa.

Although this is issued in the interest of this company, it contains much valuable information on this and other subjects. It is a well bound book of over 250 pages and has a very complete index. In addition to a large amount of information on the question of aluminum and its many uses, it contains many pages of engineering data which is of value to any mechanical engineer. We do not know the price of the book but presume it is very reasonable.

A Treatise on Milling and Milling Machines. The Cincinnati Milling Machine Co., Cincinnati, O. Price 50 cents in paper; 75 cents in cloth.

The preface says: "This treatise is published in answer to a demand from those wishing to become more familiar with the construction and use of milling machines. The important parts of the universal and plain milling machines are clearly and concisely described." A number of examples of milling operations are shown to illustrate the advantages which these machines possess for manufacturing purposes. This so thoroughly describes the book that little is left to be said unless we go into the details of the work, which, while it would be of interest, would take more space than this column affords. It would pay any shop to place a copy of this in the hands of their milling machine operatives, as it will make any bright mechanic more familiar with the machine and its possibilities. The illustrations are very clear, and, as is usual with good illustrations, they make the text perfectly plain, if not almost unnecessary, at times.

ADVERTISING LITERATURE.

THE STANDARD SIZES FOR CATALOGS ARE 9X12, 6X9 AND 3½X6 INCHES. THE 6X9 IS RECOMMENDED, AS THIS SIZE IS MOST LIKELY TO BE PRESERVED.

HILLES & JONES CO , Wilmington, Del. Catalog N. of machine tools; 44 pages, 9 x 12 inches.

This is not intended as a general catalog, but to show a few of the recent designs of this company and, in general, the line of tools manufactured by them. It is filled with good illustrations, mostly half-tones, and shows many powerful shears, punches and similar tools. Many of them are driven by electric motors, showing the increasing use of this form of motor for large tools.

TOWER & LYON. New York. Special Catalog No. 10.

This is substantially bound with flexible covers, and its 120 pages are filled with illustrations and prices of a large variety of goods. A large portion of its pages is devoted to special small tools of various kinds, among them the Belcher patent triangle and protractor, which is an extremely useful tool for draftsmen of all classes. The remainder shows the latest devices for police equipment, which are in many cases ingenious, but for which we hope our readers will have no urgent need.

APPLICATION OF PAINTS, VARNISHES AND ENAMELS FOR THE PROTECTION OF IRON AND STEEL STRUCTURES AND HYDRAULIC WORKS. Edward Smith & Co., New York.

This contains much valuable information on paints and painting as applied to steel structures and metal work generally. Much of the data this contains has been read before the A. S. M. E. and other engineering societies, so that it can be accepted as reliable. In addition to this it is embellished with a large number of excellent half-tones, showing various applications of their durable metal coating.

THE KUEFFEL & ESSER COMPANY, New York City. 1897 catalog of drawing materials and surveying instruments.

The twenty-eighth edition of this catalog has just been issued and comprises 424 pages, 6 x 9, well printed on thin paper, with round corners and flexible binding; containing complete price lists of everything required by a draftsman or surveyor, illustrated with about four hundred engravings and carefully indexed so that each article can be immediately referred to. Among the illustrations are half-tone views of the factory at Hoboken, and also of the seven-story salesrooms running from Fulton to Ann streets, New York, and used entirely for the sale of their goods. Their Chicago and St. Louis stores are also shown. This work is the standard in its line and is a veritable mine of practical information for everyone who uses drawing materials or instruments. It is sent free by the Kueffel & Esser Co., 127 Fulton street, New York City.

"LIKE THIS," is the title of the neat little leaflet just issued by Gould & Eberhardt, Newark, N.J., showing the money saving qualities of their new sand-sifter, which we illustrated in the May number. The story is told largely with pictures, the reading matter being brief and to the point. Every foundry owner should take time to send for one and read it. If we didn't know to the contrary, we should accuse W. L. Cheney of writing it, but it's a good one whoever got it up.

R. K. LE BLOND, Cincinnati, O. Catalog of machine tools.

This is considerable of a surprise, for we usually associate the illustration of machinery by half-tones in tints with the imposing cloth-bound catalogs. This catalog is neat, interesting and effective, showing a large line of tools which seem well adapted to modern requirements. There is quite a variety of engine lathes, with and without turrets. The lapping machine, pulley milling machine and bicycle crank machine, are all interesting. Then there is a line of small drilling and tapping machines with spindles to suit the work in hand. It is a catalog which machine users will want to place in their file.

THE LANE & BODLEY CO., Cincinnati, O. Price list. Machinery for transmission of power.

Anyone having shafting to erect or any belt transmission to instal, will find this particularly handy both for the list of regular sizes and the prices given. These will be of service in estimating the cost of the new lines of shafting or of alterations for a change of the machinery.

SAWYER TOOL CO., Athol, Mass. Catalog A of machinists tools.

This shows the tools manufactured by this company, many of which seem to be very handy and well adapted to the needs of the machinist. The catalog contains several pages of tables and other data for the mechanic. This includes decimal equivalents, wire and drill gauges. alloys and general information for the shop. They also sell the tools of J. Stevens' Arms & Tool Company, many of which are illustrated in the catalog.

DIETZ, SCHUMACHER & BOYE, Cincinnati, O. Catalog of machine tools.

This shows a line of engine lathes, turret lathes and drills built by this firm. The engine lathes run from 12 to 28 inch swing, of regular styles, and the Double Spindle Lathe, having a capacity of 26 inches on lower spindle and 34 inches on upper spindle, is shown, indicating the origin of this tool, which has hitherto borne a dealer's name. A plain milling machine and a crank-shaper are also illustrated and described.